Final Draft

Options for Implementing a Dynamic Net Benefits Test Based on the Billing Unit Effect

Prepared by Scott Harvey

September 5, 2012

Prepared for the ISO RTO Council

Executive Summary

FERC's Order 745 instructed the ISOs and RTOs to examine "the requirements for, costs of, and impacts of implementing a dynamic net benefits approach to the dispatch of demand resources that takes into account the billing unit effect in the economic dispatch in both the day-ahead and real-time energy markets."[1] This paper is one part of the ISOs and RTOs response to the Commission's inquiry. The basic finding of this paper is that the only method of implementing a net benefit test based on the billing unit effect using existing, known software formulations would implement the test in a very restricted manner that would have the potential to routinely produce anomalous outcomes, and even this restricted implementation would likely have adverse impacts on the solution time of ISO and RTO real-time dispatch software and day-ahead market software. These solution time impacts might in turn require simplifications in other elements of the software that would result in less efficient solutions, higher cost of meeting load, and higher prices for power consumers.

The discussion of issues associated with implementation of a dynamic net benefits test based on the billing unit effect is structured around an evaluation of four general approaches that could be taken to implementing such a dynamic test in either the day-ahead or real-time energy markets. The four approaches are:

- Attempt to develop a solution to the unit commitment and dispatch problem that applies a net benefits test based on the billing unit effect, utilizing known mathematical dual optimization techniques and equilibrium constraints;
- Attempt to develop new solution concepts that might permit a faster and better unit commitment and dispatch solutions to applying a net benefits test based on the billing unit effect;
- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect based on making all demand response bids available for dispatch versus no demand response bids available for dispatch;
- Apply an ad hoc approach to apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect from making groupings of demand response bids available for dispatch.[2]

---

[1] Order 745 at paragraph 84. The billing unit effect as specified by FERC in Order 745 compares the impact of a reduction in load in reducing the market price of power in the real-time or day-ahead market times the amount of power purchased at the reduced price (see Order at paragraph 50 to 53, and paragraph 79 footnote 162,) to the payments to demand response required to elicit that reduction in load. FERC further specified that the calculation of the benefit from the reduction in price would be applied to real-time load, without regard to the extent to which power consumers had procured power through forward contracts or the amount of power produced by vertically integrated utilities to meet their customers demand (Order at Paragraph 102).

[2] ISO New England in particular has been working to try to develop such an approach as discussed further in section IIIE below.

The first two approaches entail developing rigorous mathematical solutions to implement a net benefits test based on the billing unit effect. Either or both approaches might ultimately yield high quality solution concepts that could be implemented in commercial programs that would apply a net benefits test based on the billing unit effect in on line operation. However, both of these approaches require significant focused research efforts whose outcome and timeline is uncertain. At the end of two or three years they might produce the requirements to allow the development of programs that would yield high quality solutions to the net benefit test based on the billing unit effect within solution time frames that would be acceptable to ISOs and RTOs from an operating perspective, or they might not.

Implementation of a net benefit test based on the billing unit effect utilizing the third approach, on the other hand, would not require the development of any new solution concepts or methods, so could provide the basis for ISOs and RTOs to move forward in the near-term with the development of software to implement a dynamic net benefits test based on the billing units effect. This approach has two limitations, however, that the ISO's and RTO's should be aware of. First, the essence of this approach is that it only compares the billing unit effect benefits of making all demand response bids available for dispatch or none. This has the consequence that some demand response bids that would pass the billing unit effect based net benefits test on their own, could fail to pass the test in combination with all other demand response bids, or conversely that bids that would not pass on their own, might pass in combination with other more cost effective demand response bids. This limitation of the third approach could have undesirable consequences when the billing unit effect based net benefits test is applied in the real-time dispatch and even more undesirable consequences when applied to the day-ahead market's optimization over the 24 hours of the operating day. Second, the increase in computation time required to implement this approach would require compensating tradeoffs in terms of extending software solution time or reducing other software functionality that would tend to raise the cost of meeting load and/or adversely impact reliability or incurring the costs required to solve two cases in parallel.[3]

The fourth approach would, similar to the third approach, attempt to utilize only current software algorithms allowing a dynamic billing unit effect based net benefit test to be implemented within a defined time frame. It would attempt to avoid the undesirable consequences of the all or nothing test applied by the third approach, and apply a net benefits test based on the billing unit effect to groups of demand response bids. However, while there are ad hoc methods that could perhaps be used to apply this fourth approach to the day-ahead or real-time dispatch on an uncongested system, these ad hoc methods would not be workable when applied to a congested transmission system or to the day-ahead unit commitment, unless combined either with fundamental changes in the structure of the dispatch software or a research effort to attempt to develop algorithms or solution methods that would provide an acceptable solution within an acceptable time

[3] Some ISOs and RTOs already solve more than one dispatch case. For these ISOs and RTOs applying the net benefits test using the third approach and solving the comparison case in parallel, would require running an additional test case for each dispatch case they solve. Hence, an ISO or RTO that currently solves two dispatch cases in parallel would need to solve four dispatch cases in parallel.

frame from an ISO or RTO operating perspective as under the first and second approaches.

Beyond the implementation challenges associated with each of these approaches, implementation of a solution based on any of these approaches would require making a variety of compromises in how a net benefits test based on the billing unit effect would be applied:

- In real-time dispatch software that includes either full inter-temporal optimization or look-ahead ramp management functionality;
- In real-time pricing systems that include special pricing rules such as ex post pricing, ELMP pricing, fixed block pricing or separate scheduling and pricing passes;
- In demand response evaluations in market power mitigation passes or intra-day look-ahead scheduling and unit commitment evaluations ;
- To evaluate the billing unit effect on the day-ahead market of real-time price impacts of demand response activation;

These compromises are discussed in detail in Section IV. The critical problem in using existing software programs, algorithms and solution methods to apply a net benefits test based on the billing unit effect in a dynamic application is that the dispatch of the demand response resource would be contingent on the outcome of the net benefits test based on the billing unit effect.

Several recent FERC orders suggest that the Commission does not intend that the dispatch of demand response resources depend on the outcome of the net benefits test based on the billing unit effect, rather, it appears that the Commission intends that demand response resources be dispatched based on their bids, i.e. based on a conventional production cost minimizing benefit test, with only the nature and amount of their compensation potentially depending on the outcome of the net benefits test based on the billing unit effect. If this understanding is correct, the dispatch of demand response resources based on their bid could be implemented using existing software tools, and the application of the net benefit test based on the billing unit effect could be carried out after the fact in the settlements process, i.e. there would be no need for a “dynamic” net benefit test based on the billing unit effect in the sense of a test carried out as part of the real-time economic dispatch or in the process of clearing the day-ahead market. While the application of the net benefit test based on the billing unit effect would be complex to carry out even within an after the fact settlement process and would require some simplifications, appropriate simplifications would permit it to be applied without the development of new market software algorithms or solution concepts.

Table of Contents

Options for Implementing a Dynamic Net Benefits Test Based on the Billing Unit Effect[4]
Prepared by Scott Harvey[5]
September 5, 2012

I. Overview

FERC's Order 745 instructed the ISOs and RTOs to examine "the requirements for, costs of, and impacts of implementing a dynamic net benefits approach to the dispatch of demand resources that takes into account the billing unit effect in the economic dispatch in both the day-ahead and real-time energy markets."[6] This paper discusses the implementation choices, issues, and potential costs associated with compliance with the elements of the Commission's Order 745 that concern the implementation of a dynamic net benefits calculation based on the billing unit effect as a trigger for the activation of economic demand response.

Section II of this paper provides a high level description of the operation of industry unit commitment and dispatch software and multi-settlement systems to provide background and context for the later discussion. Section III describes the implementation issues that would be associated with application of a dynamic net benefits calculation based on the billing unit effect in ISO and RTO unit commitment and dispatch software, then describes and evaluates the four alternative approaches to implementing such a dynamic net benefits test based on the billing unit effect in ISO and RTO day-ahead markets and real-time dispatch summarized above. Section IV discusses a number of secondary

4 This paper was prepared on behalf of seven members of the ISO RTO Council, the California ISO, ERCOT, ISO New England, MISO, the New York ISO, PJM LLC, and the Southwest Power Pool. The IRC is comprised of the Alberta Electric System Operator ("AESO"), the California Independent System Operator ("CAISO"), Electric Reliability Council of Texas ("ERCOT"), the Independent Electricity System Operator of Ontario, Inc., ("IESO"), ISO New England, Inc. ("ISONE"), Midwest Independent Transmission System Operator, Inc., ("Midwest ISO"), New Brunswick System Operator ("NBSO"), New York Independent System Operator, Inc. ("NYISO"), PJM Interconnection, L.L.C. ("PJM"), and Southwest Power Pool, Inc. ("SPP"). The AESO, IESO, and NBSO are not subject to the Commission's jurisdiction, and these comments do not constitute agreement or acknowledgement that they can be subject to the Commission's jurisdiction. ERCOT is not subject to the Commission's jurisdiction with respect to the issues presented in this NOPR, but is joining in support of the IRC comments. The IRC's mission is to work collaboratively to develop effective processes, tools, and standard methods for improving the competitive electricity markets across North America. In fulfilling this mission, it is the IRC's goal to provide a perspective that balances Reliability Standards with market practices so that each complements the other, thereby resulting in efficient, robust markets that provide competitive and reliable service to customers.

5 This paper has benefitted from the comments of all of the U.S. ISOs and RTOs. It has particularly benefitted from the comments and discussion with Khaled Abdul-Rahman of the California ISO of a number of the issues considered in this paper, but any errors are solely the responsibility of the author.

6 Order 745 at paragraph 85

issues in implementing a dynamic net benefits test based on the billing unit effect that would impose limitations on the design and/or unit commitment and dispatch results that the Commission should be aware of in evaluating alternative approaches to implementing such a dynamic test.

Section V discusses FERC comments and instructions in several Order 745 Compliance and Rehearing Orders which suggest that a dynamic net benefits test based on the billing unit effect of the kind that gives rise to the implementation problems discussed in sections III and IV is not what FERC envisions for Order 745 compliance and hence is not necessary to comply with the Commissions intent in Order 745. If this understanding is correct, an alternative approach to implementing Order 745 that would apply a net benefits test based on the billing unit effect in the settlement process would be feasible.

Finally, section VI briefly summarizes the alternatives and their advantages and disadvantages in implementing the dynamic net benefits test based on the billing unit effect.

II. Design and Structure of Industry Dispatch and Unit Commitment Software

Each ISO and RTO relies on somewhat different software and processes to schedule and dispatch resources in their day-ahead and real-time energy markets, but all ISOs and RTOs coordinating such markets use software engines having four distinct components: 1) a unit commitment process; 2) a dispatch engine; 3) a powerflow calculation; and 4) a price calculation step.

These components are distinct and in the case of programs developed by some vendors, the program may cycle through these components more than once in the process of reaching a solution. The unit commitment process determines which units are on-line and available for dispatch in a particular period in the dispatch step. This is a fundamentally different optimization problem than the economic dispatch because unit commitment has binary, i.e. 0, or 1 choice variables, i.e. the unit is either off line or on line and significant costs are typically incurred to start an off-line unit and keep it on line at minimum load. Moreover, the unit commitment decision has irreversible impacts because of unit's minimum up times and down times. More complex formulations of the unit commitment problem, like the one used by California ISO, include combined cycles or multi-stage generation units with transition time, transition path, and transition cost in the unit commitment formulation adding more complexity to the solution algorithm when such a unit is (or could be) in transition from one configuration to another.

The unit commitment is therefore determined based on individual resource's start-up costs, minimum load or no-load costs, transition costs and times, incremental energy costs, minimum run time, minimum down time, and other resource characteristics such as their cost of providing various types of ancillary services. Because unit commitment is an integer variable problem, not a conventional linear programming problem, distinct solution methods, which vary from vendor to vendor, are used to determine the unit commitment.

The dispatch step determines the amount of energy that each on-line unit is to produce. In this step, the dispatch engine dispatches the available generation to meet load at least cost on a production cost basis, given the unit commitment, while taking account of resources' inter-temporal constraints, transmission constraints, both pre and post-contingency, and other requirements, such as ancillary service requirements.[7] These dispatch engines may be solved by traditional linear programming methods or in some cases using mixed integer programming. In all of these programs the re-dispatch to solve transmission constraints is based on linear shift factors representing the sensitivity of the flow on a transmission branch or flowgate to power injections at a particular bus/node.

The third component is a powerflow step which calculates the line flows associated with the dispatch solution to determine whether there are overloads of any monitored element in any base case or contingency case. The various vendors use different methods to calculate these flows, some methods entailing an AC powerflow, quasi AC powerflow solution and others use DC powerflow solutions. Some vendors in some programs solve a powerflow repeatedly as the program iterates to a solution and others do not. This powerflow step calculates the transmission overloads, if any, to be solved in additional unit commitment and/or dispatch steps, and includes criteria for determining when the line flows are within an acceptable range so that no further iteration is required.

The fourth component is a price calculation step, i.e. the step in which LMP prices are calculated. The price calculation step is carried out after the final unit commitment has been determined, and after the dispatch step has resolved any transmission constraint violations. In existing software designs, these prices are not used or even known in the process of committing generation or dispatching generation to meet load at least cost, but are determined at the very end of the program cycle. As will be discussed further in Section IV, special rules that vary from RTO to RTO sometimes apply in this price calculation step.

Another common characteristic of most US ISOs and RTOs is that they coordinate both day-ahead and real-time markets.[8] These markets are operated as multi-settlement systems in which day-ahead market schedules are settled at day-ahead market prices and deviations between real-time generation or consumption and day-ahead schedules are settled at real-time prices. These day-ahead and real-time markets are linked in ISO and RTO systems by the use of common transmission system models and constraints, [9] and at the market participant level by market participants reflecting their expectations regarding real-time conditions in their day-ahead market bids, offers and schedules.

---

[7] Most ISOs and RTOs at this point in time jointly optimize energy and ancillary service schedules in their day-ahead markets. Some ISOs and RTOs' real-time dispatch engines re-optimize ancillary service schedules in real-time while others take ancillary service schedules as given in the real-time dispatch.

[8] At present, SPP coordinates a day-ahead scheduling process rather than a complete day-ahead market but is moving towards implementation of a full day-ahead market similar to those coordinated by the other U.S. ISOs and RTOs.

[9] The transmission system representation may change between day-ahead and real-time because of changes in the status of transmission elements between the time the day-ahead market is initialized and real-time, but the models are representing the same system and constraints.

III. Net Benefits Test Implementation Choices and Issues

A. Introduction

This section discusses the core implementation issues associated with the use of a dynamic net benefits test based on the billing unit effect as prescribed by the Commission in Order 745 to trigger dispatch of demand response resources in real-time operation or to schedule them in a day-ahead market. As explained by the Commission in its order, the meaning of a "dynamic" test in this context is a test that is dynamic in the sense that it is implemented within the real-time dispatch or within the day-ahead market, because the outcome of the test determines whether demand response would be activated and hence what level of demand must be met by the real-time dispatch or the day-ahead market schedules.[10]

These core implementation issues are discussed below in the context of four general approaches that could be used to implement such a dynamic net benefits test based on the billing unit effect. The issues discussed in this section are viewed as "core" issues because they concern the ability of the ISOs and RTOs to acquire commercial software capable of implementing such a net benefits test within the ISOs and RTOs' dispatch and unit commitment processes. A number of other less central issues which concern various limitations on the accuracy of such a dynamic net benefits test based on the billing unit effect implemented using these approaches are discussed in section IV.

The fundamental consideration that drives the need for careful consideration of the method to be used to implement a dynamic net benefits test based on the billing unit effect in ISO and RTO unit commitment and dispatch software is that the net benefits calculation based on the billing unit effect is not a standard algorithm such as those currently used in electric industry dispatch software which maximize net benefits through the application of algorithms based on production cost minimization. As described in section II, existing dispatch software does not even calculate clearing prices until the dispatch problem has been solved. Hence, existing software algorithms would need to be modified to calculate clearing prices at earlier points in the process of solving the dispatch or alternatively make use of the shadow prices generated in the solution process to apply a net benefits test based on the billing unit effect. The real problem, however is that the changes in software design required to implement a net benefits test based on the billing unit effect are much more fundamental. A design, in which prices are used to determine the dispatch, rather than the least cost dispatch determining shadow prices and clearing prices, requires fundamental changes in the solution process, so existing software designs and algorithms cannot be used to directly implement the net benefits calculation.

A further consideration in implementing a dynamic net benefits test based on the billing unit effect is that all U.S. ISOs and RTOs settle their spot energy markets based on locational prices (either zonal or nodal). In these markets, power consumers pay, and

10 See Order 745 at paragraph 84

generators are paid, the price of power at their location which may differ substantially between locations on the transmission system as a result of transmission congestion. Hence, there is not a single supply curve for an ISO or RTO market, there is a supply curve for incremental power at each location within the ISO or RTO, given the dispatch of the entire ISO or RTO to meet load at all other locations. Moreover, in a market with transmission congestion, dispatching demand response to reduce or minimize net payments by power consumers or to reduce or minimize payments to generators is not equivalent to dispatching demand response to reduce or minimize gross energy market payments. This is because gross energy market payments by power consumers on a congested transmission system equal payments to generators plus congestion rents, and congestion rents flow directly (through the allocation of FTRs, CRRs, or ARRs) or indirectly (through the allocation of FTR, TCC or CRR auction revenues) to power consumers. Hence, applying a net benefits test based on the billing unit effect must deviate even further from traditional production cost minimizing solution concepts and algorithms on a congested transmission system.

The billing unit effect benefit to power consumers from the dispatch of demand response to depress spot energy prices would be measured in the presence of congestion by calculating the reduction in the net energy market payments by remaining load,[11] which could be compared to the payment to demand response providers to account for the billing unit effect in applying the net benefits test to the dispatch of demand response when there is transmission congestion.

One possible outcome from Order 745 implementation is that most or all economic demand response bids would be submitted in real-time and evaluated in the real-time dispatch. If this turns out to be the case, it would not be necessary to apply the net benefits test based on the billing unit effect in the day-ahead market and the impact of real-time demand response on day-ahead market prices would be felt through the submission of virtual supply bids and price capped physical load bids in the day-ahead market. The implications of such an outcome are discussed at length in subsection 5 of section IV below. Another possibility is that a material number of demand response bids would be submitted in the day-ahead market and their activation would be need to be determined by the application of a net benefits test based on the billing unit effect.

There are three features of the unit commitment in the day-ahead market that would make the application of the net benefits test based on the billing unit effect a more intractable problem in the day-ahead market than would be the case in the real-time dispatch. These are 1) the fundamental properties of the unit commitment problem and the methods currently used to solve it would further complicate development of new algorithms for solving the unit commitment problem based on a net benefits test that accounts for the

[11] The reference to remaining load is to the load that remains after the demand response reductions. These net energy payments by remaining load would be equal to the total energy price payments to suppliers. The calculation of net load is illustrated in the examples in Appendix A. The reference to "energy price payments" reflects the fact that this calculation would not account for the impact of dispatching demand response on uplift costs or ancillary services market prices.

billing unit effect;[12] 2) further complications introduced by the need to jointly solve the day-ahead market over the 24 hour time horizon of the operating day; and 3) the potential for the application of a net benefits test based on the billing unit effect within the unit commitment process to depress clearing prices through uneconomic generation commitment, rather than through the intended dispatch of demand response resources.

In Order 745 FERC directed the ISOs and RTOs to depart from the production cost minimizing benefits test in the dispatch of demand response if the dispatch of the demand response sufficiently depresses energy market clearing prices,[13] but has not directed that they depart from production cost minimization in making other unit commitment and dispatch decisions that would also depress energy market clearing prices and hence potentially give rise to a billing unit effect. Hence, there is a sense in which the FERC order envisions two distinct net benefits tests being applied within the unit commitment process, one based on production cost minimization and one based on the billing unit effect. These features are briefly discussed below to provide context for the discussion of alternative implementation approaches which follows.

The security constrained economic dispatch used by many ISOs and RTOs to meet load in real-time and to determine day-ahead schedules given the unit commitment generally has the properties of a conventional linear programming problem with shadow prices that correspond to clearing prices.[14] As noted in section II, however, day-ahead markets also include a unit commitment step that determines which units can be dispatched in the dispatch step. The unit commitment problem is a complex integer variable problem that cannot be solved with conventional linear programming methods. The various U.S. ISOs and RTOs and their software vendors use a variety of methodologies, including mixed integer programming, to determine the unit commitment in their day-ahead market.

Not only are existing unit commitment algorithms based on production cost minimization rather than payment minimization, the current solution algorithms for the unit commitment step do not develop explicit shadow prices (as is the case in the linear programming solution to the economic dispatch problem) that could be used as a starting point for the application of payment minimization within the unit commitment step. This lack of prices could be addressed by using prices calculated in each dispatch step to guide the iteration in the unit commitment step and either formulating the objective function in terms of prices or imposing a side constraint that accounts for price effects, but these prices will not provide a direct link between changes in the unit commitment and changes in prices and net payments by remaining load as is feasible with a production cost minimization objective function.

---

[12] These non-convexities are also present to a degree in the real-time dispatch of some ISOs and RTOs. The California ISO, for example, uses a mixed integer program to solve the real-time dispatch because of integer variables associated with non-convex multi-segment ramp rate curves and the modeling of forbidden regions.

[13] See Order 745 at Paragraphs 50-54 and 79.

[14] As noted above, this is only partially true for the real-time dispatch software of some ISOs and RTOs which relies on mixed integer programming to solve the real-time dispatch.

The second complication in determining the unit commitment is that it must be solved jointly over the hours of the day to achieve the overall least cost unit commitment, because of start-up costs, transition costs, minimum run-times, minimum load costs, ramp rates, forbidden regions, and minimum down times. Hence, all US ISOs and RTOs jointly optimize their day-ahead markets over at least a 24-hour time frame. This optimization over time in day-ahead markets has the consequence that a change in load in one hour can impact the unit commitment in a way that changes clearing prices in other hours. For example, in analyzing potential approaches to complying with Order 745 the NYISO reran a day-ahead market case with additional price capped load bids and found that the demand reduction in one hour attributable to the activation of a price capped load bid in that hour caused the clearing price to rise in the following hour. The objective of the optimization is to minimize the sum or the total cost across all hours rather than minimizing the cost of meeting load in each individual hour.

Third, it needs to be kept in mind that clearing prices could also be artificially depressed by committing excess generation in the unit commitment process and paying more than the clearing price for the generation's output (i.e. paying uplift in addition to the LMP price to cover the start-up and minimum load costs of the excess generation). Order 745, however, only orders above market payments and assignment of uplift costs to consumers for the uneconomic dispatch of demand response resources that sufficiently depresses clearing prices in ISO and RTO markets. Hence, any logic structure that is developed for use in implementing a dynamic net benefits test based on the billing units effect within the unit commitment step would need to be structured so that it would dispatch demand response to depress clearing prices based on the billing unit effect net benefits criteria (whether implemented solely through changes in the objective function or also through incorporation of sides constraints), but not uneconomically commit generation to depress clearing prices.

Maintaining such a distinction without introducing unintended consequences would be one of the additional challenges in applying a net benefits test based on the billing unit effect within ISO and RTO unit commitment processes. When the dispatch of demand response depresses clearing prices in the day-ahead market in particular, its dispatch would potentially also make the commitment of some generation uneconomic. The normal operation of ISO and RTO unit commitment software would then be to decommit the uneconomic generation that is no longer needed or economic to meet demand. However, decomitting uneconomic generation would reduce the price impact of dispatching the demand response and perhaps cause demand response activation to fail the net benefits test based on the billing unit effect as the change in the unit commitment would replace low cost generation with higher cost demand response with little impact on clearing prices.

If, however, an attempt were made to modify the unit commitment process to not decommit uneconomic generation when demand response was activated so that demand response activation would be more likely to artificially depress clearing prices, there would be a potential for the unit commitment to depress clearing prices by simply committing uneconomic generation, which would have a billing unit effect similar to the activation of demand response. One of the complications in avoiding such an outcome is that the commitment of excess generation (i.e. more than would be economic based on a production cost minimizing benefit test) that depresses clearing prices would always pass a net benefits test based on the billing unit effect, which does not consider the uplift costs that would be associated with an inefficient unit commitment but does account for the uplift costs associated with above market payments to demand response. Hence, there might be a potential for day-ahead market solutions in which no demand response is activated because clearing prices are too low, generation profits are reduced because clearing prices are artificially depressed, but consumer costs rise because too many units are on line and generators receive substantial above market uplift payments.[15]

With these considerations in mind, we describe four possible approaches to implementing a dynamic net benefits calculation based on the billing unit effect, discuss the implementation issues, general timeline and costs associated with each, and identify known issues with the quality of the solutions each approach would be capable of producing.

One possible approach would be to develop a solution to the unit commitment and dispatch problem that applies a net benefits test based on the billing unit effect utilizing known dual optimization techniques;

A second possible approach would be to attempt to develop new solution concepts that might permit a faster and better unit commitment and dispatch solutions applying a net benefits test based on the billing unit effect;

A third possible approach would be an ad hoc methodology that would apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect based on making all demand response bids available for dispatch versus no demand response bids available for dispatch;

A fourth possible approach would be to develop an ad hoc methodology that would apply a net benefits test based on the billing unit effect utilizing existing software solution methods that would allow an evaluation of the billing unit effect from making groups of demand response bids available for dispatch.

Each of these general approaches is discussed below, describing each potential approach in more detail, discussing in general terms the likely time frame in which ISOs and RTOs would have the ability to acquire commercial software that would implement a net benefits test based on the billing unit effect in the ISO's and RTO's unit commitment and dispatch software, and commenting on known properties of the solutions produced by each approach.

---

[15] As discussed below, the potential for this kind of outcome in which prices are depressed more through the commitment of excess generation than through the dispatch of demand response appears unlikely under some of the approaches discussed below (such as the third approach) but could become an issue in attempting to implement some of the other approaches.

B. Develop New Software Applying Known Methods

As outlined above, the first possible approach to carrying out a dynamic net benefits test based on the billing unit effect would be to develop a solution to the unit commitment and dispatch problem that applies a net benefits test based on the billing unit effect utilizing known dual optimization techniques. For instance, the net benefits test based on the billing unit effect could theoretically be incorporated into the ISO and RTO's optimization as a new non-linear constraint under the current production cost minimization objective function, or replace the current production cost minimization objective function with a load or billing unit effect cost minimization objective function. Both of these mathematical formulations are theoretically possible. The issue with this approach is that both formulations would have a net benefit test expression that has cross-product term of the bid megawatt dispatch variables in the corresponding constraint or in the objective function that may call for the need of non-linear optimization solution algorithms. It should also be noted that in a net benefits test formulation, the locational prices are no longer byproducts of the optimization problem as they are in the current approach and calculated as post process after the optimization. The clearing prices would now be part of the optimization formulation.

The resultant net benefits test formulation is described as a self-referential Mixed Integer Non-Linear Program problem. This type of problem formulation is known in mathematics to be extremely challenging to solve efficiently, let alone optimally, and requires long solution times due to its non-convexity, non-linearity, discreteness, and also due to the less-developed mathematical techniques required to handle such mathematical programs with difficult equilibrium constraints. Both the California ISO and ISO New England have previously provided FERC with detailed discussions of the complexity of solving this class of problem.[16] Both ISO New England and the California ISO have observed that there is no commercially available program capable of solving large scale problems of this type, let alone solving this class of problem within the solution time frame of ISO and RTO day-ahead markets or real-time dispatch.

A particularly important unknown is whether these suggested solution methods could be used or similar concepts used to apply a net benefits test based on the billing unit effect to the solution of the unit commitment problem, rather than simply to the economic dispatch. Beyond the unknown workability of applying these known solution methods to the unit commitment problem, a further deeper unknown in pursuing this approach is the workability of these solution concepts in solving the unit commitment problem if a net benefits test based on the billing unit effect is applied to some choice variables (the amount of demand response activation) and a net benefits test based on production cost minimization to other choice variations (generation commitment and dispatch) within a single unit commitment problem.

The solution concepts needed to implement a dynamic net benefits test based on the billing unit effect would need to be developed, interactions with other elements of the

[16] See Declaration of Khaled Abdul-Rahman, Docket RM10-17-001, April 14, 2011, pp 5-7.

dispatch software resolved, and execution time impacts addressed, before a dynamic net benefits test based on the billing unit effect and utilizing these prospective methods and algorithms could be implemented. There cannot be a fixed timeline for implementation of a dynamic net benefits test based the billing unit effect utilizing solution concepts and algorithms that have yet to be developed. Moreover, until the algorithms that would be used to implement the approach have been developed, evaluated, and tested, there cannot be any assessment of any potential undesirable features that might be required to implement such an approach.

C. Develop New Solution Methods; Develop New Software Applying These New Methods.

A second approach that ISOs and RTOs could take to implementing a dynamic net benefits test based on the billing unit effect would be to fund academic and/or industry research that would attempt to develop new solution concepts that might permit a faster and better application of a net benefits test based on the billing unit effect to both the unit commitment and dispatch problems. This approach could focus additional research specifically on the unit commitment aspects of the problem and explore the consequences of applying multiple benefits tests to different choice variables with the same optimization problem prior to moving forward with attempting to develop unit commitment and dispatch software for application in ISO and RTO markets.

Like the first approach, this approach is fundamentally a research project whose timeline and outcome are uncertain. This second approach has the potential to take longer than the first approach to develop and implement ISO and RTO software capable of applying a net benefits test based on the billing unit effect because of the initial time spent on further research of solution methods, but it must be kept in mind that there is no assurance that the first approach would in fact be successful. One possible outcome if the first approach is pursued is that after several years and after spending many millions of dollars on software development, it will become apparent that existing solution methods cannot provide acceptable solutions to the unit commitment and dispatch problem using a net benefits test based on the billing unit effect and that research on new solution methods must be undertaken. A key advantage of this second approach is that it might reduce the likelihood of such an outcome in which no solution is developed, and also offers the potential to avoid reliance on an approach that is sub-optimal, or excessively costly to implement. The research that would be undertaken under this approach would not only be an alternative to pursuing the first approach but is also an alternative to proceeding immediately to implement approaches three and four.

D. Modify Existing Software to Apply a Net Benefits Test Based on the Billing Unit Effect on an All or Nothing Basis

A third possible approach to carrying out a dynamic net benefits test based on the billing unit effect would be an ad hoc approach that could be carried out using only existing industry algorithms. From a software design standpoint therefore, this approach is a known quantity. While there would be detailed design issues to resolve in implementing this approach, its development would be akin to normal ISO and RTO software development projects in which these kinds of design issues are routinely resolved, trade-offs with software performance identified and addressed in one manner or another.

In its simplest form this approach would entail a three step process; solve the dispatch without activating demand response, regardless of whether it is economic, using the existing dispatch and powerflow engines, then calculate clearing prices, and then solve the dispatch again using the existing dispatch and powerflow engines but activating all demand response that would be economic to dispatch based on its bid price and calculating clearing prices based on this dispatch. The third step would compare consumer payments for energy and demand response costs (but not other uplift costs that would be borne by load),[17] between the two cases and choose which solution to base dispatch instructions or day-ahead market schedules upon, applying the net benefits test to the two solutions.[18]

This approach to implementing a dynamic net benefits test based on the billing units effect would not require development of new solution concepts but would have implications for dispatch execution time because it would require dispatching the system to meet two distinct load levels.

If the amount of demand response whose dispatch was being evaluated was sufficiently small, the difference between the two dispatches would be so small in terms of power flows and constraint impacts that the second solution would likely be quite fast.[19] We have not sought to quantify exactly how small the amount of demand response would have to be because there would not be much benefit to incurring any of these implementation costs if the amount of demand response ultimately being dispatched was relatively small. If the amount of demand response being dispatched is not small, then the software performance impact of a second complete[20] solution could be more material. One way to address potential performance problems if there were a material number of demand response bids would be to solve the two cases in parallel. This would somewhat increase the implementation costs and introduce some additional complexity into real-time operations but these impacts should be manageable.

While such a three step approach to applying a dynamic net benefits test based on the billing unit effect would likely be workable from a software implementation standpoint (i.e. able to solve the dispatch problem within the time frame required for reliable

---

[17] The discussion in this paper assumes that FERC intends that the net benefit test based on the billing unit effect would only take account of net payments by remaining load based on the energy price, i.e. would not take account of uplift payments to generators, consistent with our understanding of Order 745 and 745A.

[18] This approach can also be thought of as dispatching all demand response based on its bid, subject to a constraint that it would only be dispatch if the net benefits test were satisfied.

[19] If we recall the four components of these software programs described in section I, if the amount of demand response potentially dispatched is very small, any redispatch would be small and would likely converge immediately to the new solution with little or no change in line flows or congestion patterns.

[20] “Complete” meaning solution of a powerflow, redispatch to eliminate of congestion and iteration to an optimum.

operation of the grid by ISOs and RTOs) in this context, it would have some limitations. First, such a three step approach would account only for the options of dispatching all demand response that was economic based on its bid or none of the demand response that was economic based on its bid, which may not be the outcome the Commission intends.

Second, if there were a material amount of demand response, the activation or disqualification of all of that demand response based on an all or nothing application of a net benefits test based on the billing unit effect could cause ramp constraints on generator output changes to bind in the case in which no demand response was eligible for activation, perhaps causing a short price spike if no demand response at all were available. If this situation arose with a net benefits test based on the billing unit effect in place, one outcome could be that once a material amount of demand response was activated, the activation of all of the demand response would continue to pass the net benefits test based on the billing unit effect for some period of time, perhaps hours, because of spurious ramp constraints that would cause price spikes to be projected if no demand response were activated, although the activation of that demand response would be seen to raise consumer costs if tested over a longer period of time in which the ramp constraints ceased to bind. [21] Another possibility is that no demand response would be activated as a result of the test and a price spike would occur because all of the demand response would become unavailable in a single interval. These outcomes are not intrinsic to the use of demand response nor to the application of a net benefits test based on the billing unit effect to demand response activation but are a possible consequence of applying an all or nothing test to all demand response activation; hence a possible consequence of using this third approach to apply a net benefits test based on the billing unit effect. It is possible that these kinds of suboptimal outcomes could be avoided by the development and application of more complex ramp constraint logic in using the third approach to apply the net benefits test based on the billing unit effect, but this is uncertain and the impact of a more complex approach on software performance is also uncertain.

This approach could be applied in the presence of transmission congestion, although its impact on software performance would likely be more material and might require other changes that would raise the cost of meeting load. However, this approach could produce a variety of unintuitive outcomes when used to apply the net benefits test based on the billing unit effect on a congested transmission grid that might not be consistent with the Commission's intent.

The dynamic application of a net benefits test based on the billing unit effect utilizing this approach on a congested transmission system would require dispatching the system with no economic demand response dispatched, then with all economic demand response that is in merit dispatched, and then a comparison of the net payments by remaining load between the two cases. This net benefits calculation would be only slightly more complex than the net benefits calculation absent congestion. However, this approach to applying the net benefits test based on the billing unit effect has several unattractive features in the presence of transmission congestion that might not be consistent with

[21] This is analogous to the problem that the New York ISO had at start up with spurious price spikes due to spurious ramp constraints in the initial version of the hybrid dispatch**.**

FERC's goals. First, there is a potential with this approach for the outcome of the net benefits test for demand response at one location on the transmission system, to depend on prices and price impacts elsewhere on the transmission system. [22] While there is an intrinsic potential for the application of a dynamic net benefits test based on the billing unit effect to cause price responsive loads that pay the real-time spot price to not be dispatched off despite bids that were less than the LMP price at their location (because the bid might not satisfy the net benefits test despite being economic), the potential lack of predictability in the activation of individual demand response resources would likely be exacerbated if a dynamic net benefits test based on the billing unit effect were applied collectively on an all or nothing basis to all demand response offers across the grid of the ISO or RTO.[23]

The potential for such outcomes might discourage power consumers from attempting to respond to prices because of the unpredictability or might cause such price responsive power consumers to adjust their consumption on their own based on real-time prices rather than participating in ISO or RTO demand response programs, reducing the economic benefit from their demand response because the ISO or RTO would not be able to accurately account for their response in its unit commitment and dispatch decisions.[24]

Second, although it is difficult if not impossible to foresee the outcome of a dynamic net benefits test based on the billing unit effect applied in this manner because the outcome would depend on the amount of demand response available, its offer prices and the level of future energy prices, applying the test across the footprint of an ISO or RTO on an all or nothing basis, might cause the outcome of the net benefit test to vary more from interval to interval for many resources than would be the case if the net benefits test were individually applied to each demand response bid.[25] Such an increased degree of dispatching demand response on and off in an unpredictable manner that would be unrelated to the bid price of the demand response resource or to LMP prices at its location, might undermine the attractiveness of providing demand response through the ISO or RTO dispatch. While this potential for unpredictable variability in dispatch outcomes is intrinsic in the application of a net benefits test based on the billing unit effect, it appears that there is a potential for this to be aggravated if this approach were used to carry out the test on a congested transmission system.

---

22 This is illustrated in the examples portrayed in Appendix A.

23 This approach would by its nature sometimes cause demand response activation to fail the net benefits test applied to all in merit demand response when the application of the net benefits to a subset of in merit demand response would have passed.

24 This increased unpredictability at the resource level could also make it difficult for ISOs and RTOs to predict in advance how the net benefit test would come out, which would have adverse implications for the application of market power mitigation and look ahead in-day unit commitment and scheduling software, as discussed in subsections 4 and 5 in section IV below.

25 That is, demand response bids that would consistently pass the net benefits test if evaluated individually might pass and fail the test in an unpredictable pattern if evaluated jointly with many other bids across the footprint of an ISO or RTO.

Another limitation of this third approach would be the complexities in applying this approach across the 24 hours of the day-ahead market. One method of isolating the billing unit effect of activating demand response in a particular hour would be to solve the unit commitment for the entire day, with demand response activated in a single hour and compare the net payments by remaining load in that case to those using a unit commitment solved with demand response not activated in any hour. This process could then be repeated for each hour for a total of 25 solutions to the day-ahead market to apply the net benefits test based on the billing unit effect to demand response in each hour. This way of applying the net benefits test would, however, obviously be unworkable from a software performance standpoint because of the number of complete day-ahead market solutions required.

The unworkability of applying such an approach could be reduced by executing the 25 day-ahead market solutions in parallel on multiple systems, then using the results of these solutions to apply a net benefits test based on the billing unit effect on an hour by hour basis to determine in which hours the bids would be active. The day-ahead market would then be solved in a final run based on the results of the net benefits test applied to these parallel solutions. Such an approach would require extending the time frame of ISO and RTO day-ahead markets and would entail the additional costs and implementation complexity of solving 25 day-ahead market cases in parallel but would not require the development and application of any new solution concepts or algorithms. However, the results from applying such an approach might provide a very poor measure of the actual billing unit effect if demand response passed the net benefits test based on the billing unit effect in several hours but not in other hours, as the market solutions for the runs which determined the activation status for demand response would potentially have quite different unit commitments, so the results of combining the demand response activations over the day would quite likely lead to results that were different from those in any of the 25 cases.

Another method to account for the inter-temporal effects would be to solve the day-ahead market twice, once with no demand response activated and once with all demand response activated, and apply the net benefits test based on the billing unit effect to total demand response costs and net payments by remaining load over the day, with all demand response over the day either passing or failing the net benefits test. A limitation of this way of solving the problem would be that demand response bids in some hours might be cost effective yet fail the net benefits test because other demand response bids would not be cost effective in other hours. In particular, demand response in peak hours might not pass the test because its impact would be tested in combination with demand response in off-peak hours that might not be cost effective as measured by the test. An advantage of this approach beyond its simplicity is that demand response activation in the market run would be consistent with the results of the net benefits test.

A third method of accounting for the inter-temporal impacts of demand response in applying a net benefits test based on the billing unit effect would involve solving the day-ahead market three times, once with no demand response activated and once with all demand response activated.[26] The net benefits test based on the billing unit effect would then be applied to demand response in each hour separately based on the results of the two initial runs, assuming that any difference in net payments by remaining load in a particular hour between the two cases was a result of demand response activated in that hour. Then the day-ahead market would be solved a third time with demand response available for dispatch only in the hours in which it passed the net benefits test based on the billing unit effect as applied to the two initial runs. A final step would choose the solution with the lowest net payments by remaining load.[27] This third method of accounting for the inter-temporal impacts avoids some of the limitations of the first and second methods but has several limitations, a) demand response might not be activated in a particular hour because of price increases due to changes in the unit commitment in other hours; b) the billing unit effect in the third day-ahead market solution could be quite different from those in the other two solutions because demand response would be turned on in some hours but not in other hours, resulting in different unit commitments.

From a practical standpoint, the net benefits test based on the billing unit effect would need to be applied using either the second or third of the alternatives described above because of the unworkable performance impacts of the first alternative, unless it were implemented by running the 25 cases in parallel.

Overall, this third approach to applying the net benefits test based on the billing unit effect on a dynamic basis either in the real-time dispatch or day-ahead market does not, at least in its simplest form, require development of any new algorithms or solution concepts, so could be implemented. The actual performance implications of this approach on market software would need to be examined by each ISO and RTO individually given their market design and software execution requirements and each ISO and RTO might find it necessary to make compromises in other elements of their real-time dispatch or day-ahead market solutions in order to accommodate the dynamic application of the net benefits test based on the billing unit approach using this approach.

The key limitations of this approach are the consequences of the all or nothing application of the test across demand response bids at different price levels, different locations, and, in the context of the day-ahead market, different hours of the day.

E. Modify Existing Software to Apply a Net Benefits Test Based on the Billing Unit Effect to Groups of Demand Response Bids.

A fourth possible approach to implementing a dynamic net benefits test based on the billing unit effect within ISO and RTO economic dispatch programs would be structured to take account of the possibility that if there are many demand response bids, the activation of all of the economic demand response bids might fail a net benefits test based on the billing units effect, but activation of a portion of the demand response bids could pass the net benefits test. Absent development of new algorithms and solution methods

[26] These two runs could be run in a parallel to reduce solution time.

[27] Because of unit commitment differences, it cannot be assumed that either the production costs or payments to generators would be lower under the third solution than for the first or second solution.

as discussed above with respect to the first approach, applying a dynamic net benefits test based on the billing unit effect that distinguishes between these two situations would entail an iterative approach in which the dispatch would be solved for incremental levels of demand response activation, with the goal of determining the optimum level of demand response activation based on the net benefits test criterion[28] within an acceptable number of iterations from a performance standpoint.

If there were a material number of demand response offers, attempting to evaluate the billing unit effects associated with the dispatch of individual demand response bids would likely make this fourth approach much more unworkable than the third approach from the standpoint of dispatch execution time.[29] Moreover, even if there were generally only a small number of demand response offers, this kind of approach would still be unworkable because ISOs and RTOs could not be assured that there would always be a small number of demand response offers to be accounted for and would not be able to rely upon real-time dispatch software that would sometimes solve within the required time frame and sometimes not. [30]

One way to reduce the number of incremental levels of demand response evaluations required to implement the fourth approach would be to apply the net benefits test based on the billing unit effect to bids within specified bid price ranges, rather than to each individual demand response bid, e.g. to test all demand response bid at less than $50, then all bid at less than $55, then all bid at less than $60 etc.[31]

A fundamental barrier to implementing the net benefits test using these kinds of approaches is that they would not be feasible on a congested transmission system or in the context of the unit commitment problem in the day-ahead market (or potentially in real-time dispatch software that has to solve similar non-convexities such as the California ISO's dispatch software).

First, it would not be possible to apply a price based grouped evaluation to demand response bids on a congested transmission system because demand response at different

---

[28] It is presumed that the "optimum" in this situation would be the largest amount of demand response that could be activated based on its bids and satisfy the net benefits test. Another possible criterion would be the level of demand response activated based on its bids that would maximizes the pecuniary benefit to load as calculated based on the net benefits test.

[29] This fourth approach would also have the unattractive property that there would often be situations in which some but not all of the demand response bids submitted with prices less than the actual clearing price would be dispatched. This situation would likely be confusing to market participants but is not obviously worse than the outcome under the third approach in which it might often be the case that none of demand bids submitted with prices less than the actual clearing price would be dispatched.

[30] ISO New England has experimented with an iterative approach that would incorporate the net benefits test into the solution to an energy-only, single interval real-time dispatch problem but ISO New England does not believe that this approach is worth pursuing further for a variety of reasons that the ISO discusses in its compliance filing.

[31] It might be possible to reduce some of the adverse performance impacts of this approach by using ISO and RTO bid validation processes to identify the price intervals that would be used for the evaluation prior to solving the dispatch problem (i.e. if no bids were submitted between $50 and $55, that bid interval would not need to be tested).

locations could have different price impacts, even if they had the same offer price. [32] While the shift factors used in congestion management would provide information regarding the impact of demand response on flows on binding transmission constraints that could be used in evaluating price impacts, the application of the net benefits test based on the billing units effect on a congested system would need to account for the differential impact on demand response at different locations on constraint shadow prices and congestion rents, which would entail development of new solution concepts.

More generally, any grouping of demand response bids for evaluation in applying the net benefit test using existing software solution concepts would have to group them by location, and any grouping by location would require rules for defining constrained regions based on shift factors or congestion components, and require special rules to cover situations in which demand response activation causes transmission constraints to change from binding to non-binding or non-binding to binding.

While it would be straightforward to group bids by location on a simple radial network with closed interface constraints, transmission congestion is not confined to closed interfaces but typically also includes congestion on open interfaces and pre- and post contingency line constraints. When transmission congestion is not limited to closed interfaces demand response bids with the same price but at different locations could have different impacts on clearing prices and very different net benefits, even if there was only one binding transmission constraint. If ISOs and RTOs were to attempt to apply a net benefits test based on the billing unit effect using this fourth approach and known solution methods, they would have to apply the test using a small number of pre-defined geographic regions to group demand response bids for evaluation, and FERC would have to accept the fact that the groupings would often not reflect the actual congestion pattern and that the results of the test would not always, or maybe not even often, provide even a roughly accurate measure of the billing unit effect.

If ISOs and RTOs used say four geographic regions and four price range groupings to simplify the application of this fourth approach, that would require 17 solutions of the dispatch in order to apply a net benefits test based on the billing unit effect to the bid groupings (16 cases with demand response activated in a given region for the various price groupings and one case with none activated), then a final dispatch using the bids that passed the test. It is hard to envision how the ISOs and RTOs could possibly solve the dispatch 18 times within the normal time frame of the real-time dispatch even taking advantage of every possible design change and performance improvement, so the only way to implement a net benefits test based on the billing unit approach in this manner would be to solve the 17 cases in parallel and feed those results into the actual dispatch engine for the final dispatch that would determine dispatch instructions. This would be expensive and would require a substantial time to implement in order to structure the parallel solutions but would not require the development of any new solution concepts.[33]

[32] This is illustrated in appendix A.

[33] This complexity does not exist in the convention production cost based net benefit test because the benefit of accepting each individual bid can be determined based on its impact on the cost of meeting load without solving the entire dispatch problem as required by this fourth approach.

The performance problems associated with applying fourth approach to more than a very small number of demand response offers in the context of the dispatch problem would become even more unworkable in the context of the unit commitment process in day-ahead markets because of the features of the day-ahead market described above: a) the non-convexity of the unit commitment problem, and b) interactions across the 24 hours of the day-ahead market. It would not be workable to solve the day-ahead market for 17 different locational and pricing groupings of demand response, and do this 24 times for each hour, requiring 408 parallel solutions. Moreover, because of the interactions across hours and locations in the unit commitment, it is uncertain whether solving these 408 cases in parallel, then applying a net benefits test based on the billing unit effect to the demand response in the individual hours, locations and price groups, would even produce outcomes consistent with a net benefits test for the day as a whole.

A method that might be used to apply a net benefits test based on the billing unit effect to groups of demand response bids in ISO and RTO day-ahead markets would be to exclude demand response bids from the initial steps of the day-ahead market in which the unit commitment is determined and only allow these bids to be dispatched in a final price determination step in which the unit commitment is fixed. This approach would require dispatching each hour 17 times to apply a net benefits test based on the billing unit effect to 16 location/price groupings, and then solving a final dispatch based on the results of the test, but would not involve any development of new unit commitment algorithms.

Even this approach to implementing a net benefit test based on the billing unit effect would be unworkable in any day-ahead market in which demand response suppliers are permitted to submit start-up bids,[34] because demand response bids that are composed of both a dispatch price and a start-up cost cannot be evaluated without taking account of both costs, so cannot be grouped based on dispatch bids alone as required to implement this approach.

As would be the case for the real-time dispatch, the application of the net benefits test based on the billing unit effect to these groupings, might or might not produce a final dispatch that satisfies the net benefits test even for demand response in aggregate, let alone at the level of the individual bid. This potential is intrinsic in the use of approximate locational groupings, a limited set of price groupings and applying the test independently to each hour and could not be avoided if this fourth approach were used. Moreover, it would not be possible to accurately assess how frequently this would be the case until software based on the fourth approach was designed, built and placed in operation. Once an ISO or RTO had such day-ahead market software available, it could run test cases on historical day-ahead market data to get some sense of the quality of the solution produced by this approach, but it likely would not be able to accurately assess how accurately it would apply the net benefits test based on the billing unit effect until it

[34] The New York ISO's Day-Ahead Demand Response Program, for example, allows participants to submit start-up cost bids, see New York ISO Market Services tariff attachment D and New York ISO Day-Ahead Demand Response Program Manual, July 2003 pp. 14-15**.**

had actual demand response bids and observed how those bids and the software design changed the bids of other market participants, including virtual traders.

The activation of demand response after the unit commitment is fixed would also maximize the apparent impact of the demand response activation on clearing prices in the day-ahead market because no units could be decommitted in response to the reduced prices. [35] However, if the generators scheduled in the day-ahead market whose operation is made uneconomic by the activation of demand response are not committed during the operating day and do not actually operate in real-time; this would tend to raise real-time prices above day-ahead market prices. Such a price differential would in turn incent the submission of additional virtual demand bids in the day-ahead market that would undo some of the impact of the uneconomic demand response on day-ahead market prices by driving up day-ahead market prices both in the unit commitment steps and in the final dispatch that determines prices in combination with demand response. Hence, it could be case that the settlement prices calculated in the pricing step of the day-ahead market reflecting the activation of demand response would pass the net benefits test if compared to the elevated prices in the unit commitment steps that would be driven by virtual demand bids, yet would fail a net benefits test if compared to prices in a day-ahead market cleared to minimize production costs.

F. Conclusions

If the first or the second approaches to implementing a dynamic net benefits test based on the billing unit effect were taken, it would be necessary for the ISOs and RTOs to invest some millions of dollars and perhaps a few years, or a number of years, in modifying existing or developing new software algorithms which could consistently apply a net benefits test based on the billing unit effect within the corresponding market run-time window required for use in ISO and RTO real-time dispatch software and day-ahead markets. Hence, if the first approach were taken, there could be no assurance that a solution would be developed, and commercial software implemented, within a predefined time frame. One possible outcome could be that after several years it would become apparent that these methods would not produce a satisfactory solution and another approach would have to be selected.

The only approach that could provide any assurance that a dynamic net benefits test based on the billing unit effect could be implemented in commercial software within the next few years would be the ad hoc third approach, in which only two levels of demand response activation (all or none) are evaluated. Even so, the implementation of the third approach might require simplifications in other elements of the real-time dispatch software along with many simplifications in market design rules related to inter-temporal constraints to maintain performance, and these simplifications may raise the actual, not

[35] It needs to be noted that the net benefit calculation based on the billing unit effect described by the Commission would not take account for the increase in uplift payments to generators associated with a reduction in prices if the unit commitment were held fixed, as well as not accounting for its impact on capacity market payments, or its lack of impact on power purchased under existing energy contracts or by vertically integrated utilities.

merely pecuniary, cost of meeting load. Similarly, implementation of the third approach to applying a dynamic net benefits test based on the billing unit effect within day-ahead markets may require simplifications in day-ahead market design that reduce the efficiency of the day-ahead market and potentially raise the uplift costs borne by energy consumers.

The fourth approach would, like the third approach, not involve the development of any new software solution concepts or algorithms, but absent development of new solution concepts, it would require very fundamental changes in the way real-time dispatch software operates (some number of parallel solutions feeding into a final dispatch) that would entail major changes in ISO and RTO dispatch systems. This approach would therefore, even in the best case, require one or two more years to implement than the third approach and its implementation complexity has the potential for operational issues to emerge as the details are worked out that would stretch the implementation timeline even further into the future.

IV. Other Design Choices and Market Impacts

Beyond the core design issues associated with the fundamental choice of the approach used to develop software that would apply a net benefits test based on the billing unit effect in ISO and RTO unit commitment and dispatch software, there are a number of secondary design choices that would need to be made in order to utilize that software within the existing ISO and RTO market designs and operating practices, without regard to which of the potential approaches to implementing a dynamic net benefits test based on the billing units effect is selected. The major issues associated with an "dynamic" net benefits test based on the billing unit effect that would need to be addressed are listed below:

- Application of a net benefits test based on the billing unit effect in real-time dispatch software that includes inter-temporal optimization will require that the Commission accept that the test results will not always be consistent with prices;

- Application of a net benefits test based on the billing unit effect will be implemented in ways that will not be consistent with settlement prices determined by special ISO and RTO pricing rules and ISO and RTO pricing and dispatch rules will in some circumstances require that demand response resources be dispatched to maintain reliability without regard to the outcome of a net benefits test based on the billing unit effect;

- The implementation of the net benefits test based on the billing unit effect in ISO and RTO real-time dispatch software would not be able to account for the impact of real-time price reductions on the day-ahead market supply curve;

- Interaction between basing activation of demand response based on a net benefits test based on the billing unit effect and ISO and RTO market power mitigation mechanisms could have unpredictable effects that would need to be examined carefully and might require implementation approaches that would lead to inconsistency between real-time prices and those used to apply the net benefit test.

- Basing activation of real-time demand response on a net benefits test based on the billing unit effect will impact ISO and RTO day look-ahead scheduling and unit commitment evaluations in ways that are likely to raise the production cost of meeting load and increase real-time price divergence between ISO and RTO markets.

- Basing activation of real-time demand response on a net benefits test based on the billing unit effect will hinder development of ramp management tools being developed by some ISOs and RTOs to reliably accommodate higher levels of intermittent generation output and will likely preclude real-time demand response from being able to provide ramp capability in those markets if and when they are implemented.

Each of the above listed issues is described and discussed below. A number of the issues would impact the implementation of a net benefits calculation based on the billing unit effect either as part of a day-ahead market and as part of the real-time dispatch, while some others would primarily impact either day-ahead or real-time benefits calculations.

A. Interaction with real-time dispatch software that includes inter-temporal optimization.

ISO and RTO real-time dispatch software increasingly incorporates functions that optimize some element of the dispatch over more than one dispatch interval.[36] Multi-period optimization is currently used by New York ISO and California ISO in their real time dispatch software (this is also sometimes referred to as "look-ahead dispatch)." Moreover, MISO, ERCOT and ISO New England are considering implementing real-time dispatch software with such inter-temporal optimization over the next perhaps 4-5 years. The economic benefit to power consumers from the use of inter-temporal optimization in the real-time dispatch is that it enables the dispatch software to reduce the production cost of meeting load by accounting for known future changes in demand or supply that would require the dispatch of very high cost generation due to ramp constraints. By dispatching low cost generation to begin moving up in advance of these changes, or high cost generation to begin moving down in advance, the cost impact of these ramp constraints can be reduced.

The kind of known future changes in demand or supply that can be taken into account in the real-time dispatch software include projected high rates of demand increase during portions of the early morning load pickup, large changes in scheduled inter-change at the

[36] All ISO and RTO day-ahead markets optimize the unit commitment and dispatch over the 24 hour horizon of the operating day. The issues involved in implementing a net benefits test based on the billing units effect within these day-ahead markets are discussed in section IVC.

top of the hour, large pumps going on or off line, scheduled transmission outages that change congestion patterns, and scheduled generation commitments or decommitments.

The ISOs and RTOs currently using or planning to implement inter-temporal optimization in their real-time dispatch would need to apply the net benefits test based on the billing unit effect in a simplified manner that would in some circumstances lead to inconsistencies between actual settlement prices and the outcome of the net benefits test based on the billing unit effect. The key problem is that the reason for developing dispatch software that optimizes over time is that the optimal dispatch for the current interval can depend on the demand and supply balance of future intervals. This in turn implies that the optimal dispatch for the current interval can depend on whether demand response will be activated in future intervals.

Projecting whether generation or demand response would be economic in future intervals is inevitably uncertain, but it is manageable in the normal implementation of inter-temporal optimization because if demand and prices are high in a future interval, high cost generation or demand response would be dispatched and if prices are not high, they would not be dispatched. Hence, if generation were dispatched up in the current interval because high prices were projected in future intervals, those high prices would also cause the look-ahead dispatch based on those high prices to take account of demand response activation. However, if the activation of demand response in future periods would be based on application of a net benefits test which accounts for the billing unit effect, there would be no such direct link between the LMP price at the location of the demand response resource in the future period and demand response activation, because demand response activation would depend on the outcome of a net benefits test based on the billing unit effect, not just on the LMP price and bid of the demand response resource. Hence, it would be necessary for the forward looking evaluation to not only predict whether activation in these future intervals would be economic based on the projected LMP price at that location, but to also predict also whether activation would pass a net benefits test based on the billing unit effect. Whether this could be accomplished within a time frame that is acceptable to ISOs and RTOs from the standpoint of software performance, or if could even be accomplished at all, is doubtful.

Two of the approaches discussed in section III entail the development of new software solution methods based on either known concepts or concepts yet to be developed. It is obviously not known at this point in time how those solution methods might be integrated with the inter-temporal optimization in real-time dispatch software or what compromises might be required for such an implementation.

If a net benefits test based on the billing unit effect were applied using the third approach, i.e. collectively to all in merit demand response bids, it would similarly be possible to apply the net benefits test based on the billing unit effect collectively to the current and future intervals. This approach could, however, potentially lead to odd outcomes in which demand response would be activated in the current period because of projected net benefits in future periods or not activated in the current period because future periods failed the net benefit test. A variation on the third approach would be to apply the net benefits test based on the billing unit effect based on single interval dispatches with all demand response activated or not activated, then carry out the full multi-period optimization with demand response either activated or not activated in the initial interval based the outcome of the net benefits test applied to the current interval, and not activated in future intervals.[37]

One potential undesirable side effect of such an approach would be that the real-time dispatch software might at times dispatch up generation out-of-merit in the current interval to meet load in future intervals that might have been met at lower cost through demand response activation, thus causing demand response to not be dispatched in circumstances in which it would have been economic absent the software simplifications needed to implement a net benefits test based on the billing units effect. In addition, there could be situations in which demand response would pass the net benefits test based on the billing unit effect when applied based on the single interval dispatch, but would not have passed the test based on the settlement prices determined in the final inter-temporally optimized dispatch. The Commission would have to accept these possibilities if the third approach were used to implement a bet benefits test based on the billing unit effect and applied in this manner.

Using the fourth approach to apply the net benefits test based on the billing unit effect in real-time dispatch software that optimizes over time would require solving the 17 cases, assuming four geographic regions and four price range groupings, in parallel in a single interval dispatch, then applying the results of those runs to determine which demand response bids would be available in the final multi-interval dispatch. The fourth approach would have essentially the same limitations as the third approach when applied to software that optimizes the dispatch over time as well as the limitations of the fourth approach discussed in section III.

The central problem with implementing a net benefits test based on the billing unit effect in this manner in real-time dispatch software that optimizes over time is that it would add two single interval dispatch steps to software which already requires substantial execution time in order to carry out the inter-temporal optimization. Ending use of inter-temporal optimization by the New York ISO and California ISO and require other RTOs to abandon their efforts to reduce the actual resource cost of meeting load and improve reliability through improved optimization in order to implement a net benefits test focused on achieving billing unit effects would not be a good tradeoff for power consumers.

---

[37] Alternatively, the ISOs and RTOs could assume that demand response would be activated in future intervals if economic. The presumption of this approach would be that if the absence of demand response in real-time caused a major price spike, demand response activation would pass the net benefits test based on the billing unit effect. However, if there is a material amount of economic demand response the ISOs and RTOs would need to very carefully evaluate and test the implications of such an approach once the details are worked out to make sure that there are no unintended consequences from implementing such an approach.

Hence, while inter-temporal optimization would not preclude application of a net benefit test based on the billing unit effect, FERC would have to accept the kind of simplifications described above and the fact that the activation decision would not always be correct if evaluated against its impact on settlement prices.

B. Interaction with special RTO pricing rules

A number of ISOs and RTOs have special dispatch rules that are used to determine settlement prices in addition to the core physical dispatch that determines base points. Applying a net benefits test based on the billing unit effect to settlement prices calculated in accord with these special pricing rules would add complexity, slow the dispatch execution, potentially require too many iterations to be practical and in some cases would be simply infeasible because settlement prices are calculated after the dispatch interval is over (i.e. in ex post pricing systems). These complexities would be reduced if the Commission were to accept that the prices used to apply a net benefits test based on the billing unit effect would differ at times from actual settlement prices and accept that the net benefits test based on the billing unit effect would not be employed to determine demand response activation in some circumstances.

Four types of special pricing rules are considered below: ex post pricing, fixed block pricing, the California ISO pricing pass and scarcity pricing.

PJM, ISO-NE, and MISO use various versions of ex post pricing systems in which settlement prices are determined after the dispatch interval is over, using information regarding the response of generators to their dispatch instructions, to calculate settlement prices. It would obviously be infeasible to apply a dynamic net benefits test based on the billing unit effect to determine demand response activation based on ex post prices that would not be determined until after the fact. Hence, in these markets any dynamic net benefits test based on the billing unit effect would have to be applied to prices calculated from the ex ante dispatch instructions, which at times would turn out to be higher than actual settlement prices.

The New York ISO has multiple pricing passes in its real-time dispatch to allow fixed block units (such as gas turbines that are dispatched to their upper limit when operating) to set prices in some circumstances. In order to ensure that fixed block units only set clearing prices when they are needed to meet load, the price calculation process in the real-time dispatch involves three distinct dispatch-passes. Moreover, in order to avoid spurious ramp constraint driven price spikes arising from differences in generator dispatch points among the various passes, the New York ISO dispatch has special logic to determine the application of ramp constraints across these passes.[38]

Beyond the adverse performance impact of solving another three pass dispatch in order to compare prices with and without activation of demand response, we noted above with regard to the third approach that if there were a material amount of demand response available for dispatch the use of all on or nothing net benefits test based on the billing

[38] NYISO Tariffs – Attachment B, section 17.1.2

unit effect to determine demand response activation could lead to short ramp constraint driven price spikes. Any application of the net benefits test based on the billing unit effect and utilizing the third approach would need to be tested to identify any unintended consequences arising from interactions between the existing hybrid pricing logic embedded in New York ISO real-time dispatch software and the way the net benefits test would be applied on the all or nothing basis and it might be necessary for the Commission to accept some degree of anomalies in the application of the net benefits test based on the billing unit effect.

Similarly, under the fourth approach it would be necessary to test for interactions between the anomalies that would inevitably arise from the individual activation of demand response in locational and price groups and the hybrid pricing dispatch, and again it might be necessary for FERC to accept some degree of anomalies in the application of the net benefits test based on the filling unit effect. Until any software developed to implement a net benefits test based on the billing unit effect and utilizing the first or second approach was actually available, it is obviously impossible to project what interactions might exist with the hybrid dispatch logic and what compromises might need to be accepted in implementing such a net benefits test using those approaches. Until this evaluation has been completed there can be no assurance that any approach selected would generally produce accurate applications of a net benefits test based on the billing unit effect when implemented in conjunction with the New York ISO's current market design. However, the alternative of eliminating the NYISO fixed block pricing logic in order to more accurately implement a net benefits test based on the billing unit effect would likely have serious adverse effects on the efficiency of the NYISO market. Moreover, the impact of eliminating the hybrid pricing dispatch might be to so reduce clearing prices that demand response would rarely if ever be economic in eastern New York, which is likely not the outcome the Commission sought with Order 745.

Similar issues would apply to the extended LMP formulation that the Midwest ISO has developed and filed for approval with the Commission in order to address pricing inconsistencies that contribute substantially to excess Revenue Sufficiency Guarantee charges. [39]

The California ISO utilizes a third type of special pricing rule. The California ISO determines physical dispatch schedules in an initial dispatch pass with very high penalty values on some kinds of constraints to control priority of relaxation of various constraints in cases of infeasibility, then determines settlement prices based on a second pass (pricing run) in which constraints violated in the first pass have been relaxed. Because physical dispatch instructions are determined in the initial physical pass (scheduling run) it would be desirable to apply the net benefits test based on the billing units effect in this pass to make sure that the physical dispatch accounts for demand response activation, regardless of which approach is used to implement a net benefits test based on the billing units effect.

[39] See MISO filing in Docket ER12-668-000 December 22, 2011.

It would, however, be necessary from a reliability standpoint to include an override that would activate demand response without regard to the impact of the net benefits test if transmission and other constraints were violated in the physical dispatch pass, to ensure that demand response able to solve these constraints would be activated.[40] Applying a net benefits test based on the billing units effect in the physical dispatch pass could at times cause demand response to be activated when it would not be economic or not pass the net benefits test if the billing unit effect were calculated based on settlement prices, which can be very different from the shadow prices in the physical dispatch pass.

A fourth type of special pricing rule is reserve shortage pricing, currently used by the New York ISO for reserves and regulation, [41] the Midwest ISO for operating reserves, [42] ISO New England for reserve shortages, and the California ISO for operating reserve and regulation scarcity pricing. [43] In addition, FERC has recently approved PJM's proposal to implement reserves shortage pricing,[44] and the Midwest ISO plans to implement shortage pricing for spinning reserves.[45] A fundamental problem with applying a net benefits test based on the billing unit effect to the activation of demand response during reserve shortage conditions is that it would clearly be appropriate from a reliability standpoint to activate demand response during such conditions, however there would be a potential for activation to fail the net benefits test based on the billing unit effect if there were not enough demand response to eliminate the reserve shortage or to materially reduce the marginal energy offer price, so that energy prices would be set at essentially the same level whether demand response was activated or not.[46] Such an outcome in which demand response is not activated during shortage conditions could be avoided by implementing additional logic that would ensure that demand response would be activated in reserves shortage conditions without regard to the outcome of a net benefits test based on the billing unit effect.

Overall, a dynamic net benefits test based on the billing unit effect could be implemented in combination with most ISO and RTO special pricing rules as long as the Commission accepted that the test would have to be applied based on prices that could differ from final settlement prices and allowed the application of a net benefits test based on the billing unit effect to be suspended and conventional bid based production cost minimizing benefit rules to be used in some situations, such as during reserve shortage conditions. There might be interactions between the application of a net benefits test based on the billing unit effect and fixed block pricing rules, particularly under software

---

[40] Prices in the physical pass could be set by constraint violation penalties and hence the level of prices could change little with demand response activation if the amount demand response was not sufficient to solve the constraint violation, yet it would not make sense from a reliability standpoint to not activate demand response in these circumstances.

[41] NYISO Tariffs MST Sections 15.3 and 15.4.

[42] Midwest ISO Tariff, section 40.2.13

[43] California ISO Tariff section 27.1.2.3.

[44] See PJM June 18, 2010 filing in Docket ER09-1063-006 and 139 FERC Par 61,057 April 19, 2012

[45] Midwest ISO, "Spinning Reserve Demand Curve – Construct," Market Subcommittee, January 6, 2012; Midwest ISO filing, Docket ER12-1185-000, March 1, 2012; 139 FERC Para 61,081, April 30, 2012.

[46] Demand response would be activated in these circumstances if the activation decision were based on production cost minimization rather than payment minimization as activation would reduce the degree of reserve shortage even if it had little or no impact on clearing prices.

developed under the 1st and 2nd approaches, which might be more difficult to resolve. Whether this would turn out to be an issue could not be fully resolved until the software design for implementing a net benefits test based on the billing unit effect under one of those approaches was actually developed.

C. Accounting for the real-time price reductions on the day-ahead supply curve

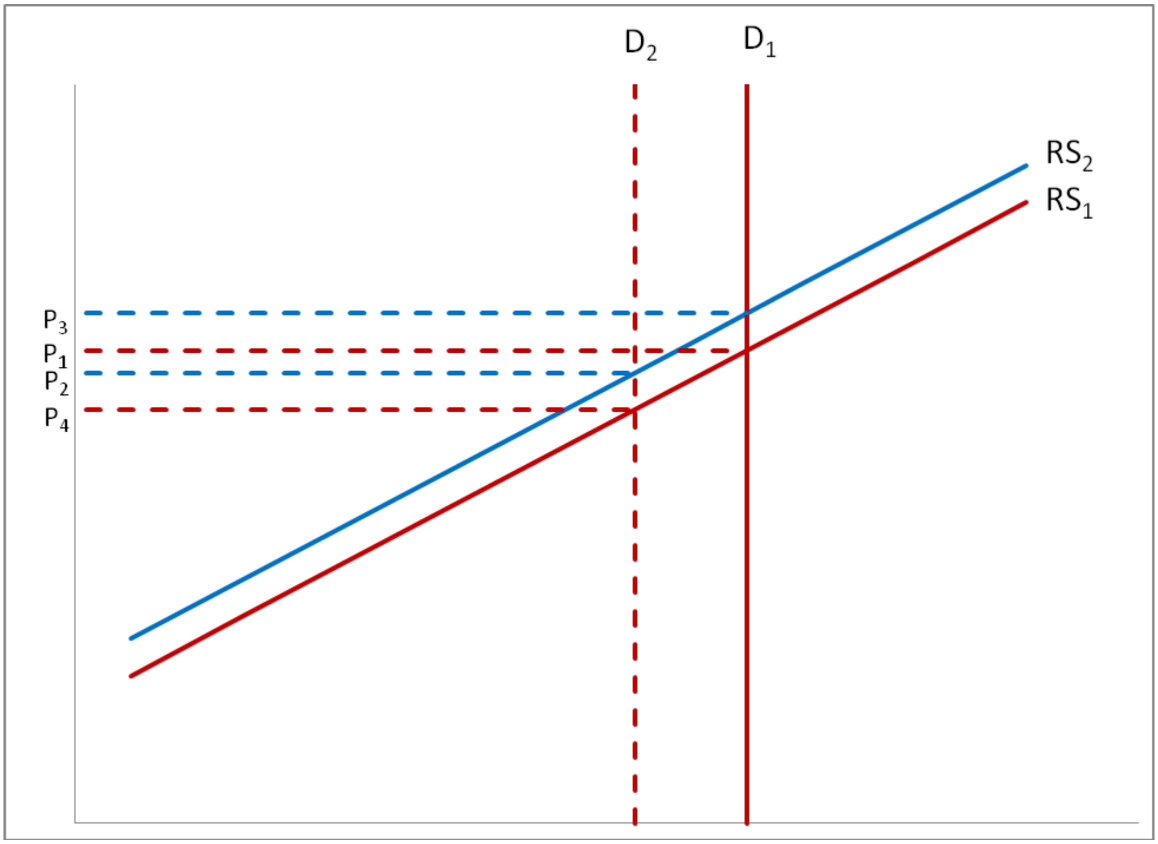
While the real-time market plays an important role in maintaining reliability and ensuring that electric load is met at least cost, very little power is typically purchased by load serving entities at real-time prices; 5% or less of real-time load is typically settled at the real-time price. Instead, most power consumption is scheduled day-ahead and priced in the day-ahead market, and may be further hedged by bilateral long-term contracts or vertical integration of the load serving entity into power generation.

The activation of demand response to reduce real-time spot prices does not directly provide a billing unit effect benefit to power consumers or their load serving entities that have purchased power in the day-ahead market. Indeed, if demand response activation reduces real-time load below the load cleared in the day-ahead market and causes real-time prices to decline below day-ahead market prices, this would benefit suppliers who would be able to buy back their day-ahead positions at prices lower than their incremental costs, earning larger profits than if demand response had not been activated and they had operated their generation to meet the higher load level.

Any long run billing unit effect benefit to power consumers from paying for the activation of demand response resources in order to depress real-time prices requires that the lower expected real-time prices attributable to demand response activation be reflected in day-ahead market prices through additional virtual supply bid into the day-ahead market or reduced physical load bid into the day-ahead market. However, the introduction of additional virtual supply offered in the day-ahead market or reduced physical load bid into the day-ahead market that reduced clearing prices in the day-ahead market would also impact the unit commitment in the day-ahead market by making it uneconomic to commit as much generation as would otherwise have been the case. The reduced commitment of generation in the day-ahead market would reduce the billing unit effect benefit in the day-ahead market to consumers from the price depressing effects of the real-time demand response as day-ahead prices would not fall as much as would have been the case if the unit commitment were held constant.

This is illustrated in Figure 1. RS-1 portrays the real-time supply curve that would be produced by the day-ahead unit commitment if a real-time demand of D1 were expected. Given this supply curve and real-time demand of D1, the real-time price would be P1. D2 portrays the real-time demand with demand response of D1-D2, and RS-2 portrays the real-time supply curve that would be produced by the day-ahead unit commitment if a real-time demand of D2 were expected. The introduction of demand response therefore reduces the real-time price from P1 to P2. If one uses the real-time supply curve RS-2 to project what prices would have been absent the demand response with a demand of D1, the projected price would be P3, rather than the actual P1. Hence, using the real-time supply curve to apply a net benefits test based on the billing unit effect overstates the billing unit effect by P3-P1.

Figure 1
Shifts in Real-Time Supply Curves



Prices P1 and P2 are the points on the day-ahead supply curve associated with demand levels of D1 and D2. Hence, accurately measuring the billing unit effect benefit to consumers from paying for real-time demand response in order to depress real-time prices requires calculating the benefits based on the day-ahead market supply curve, rather than the real-time supply curve.

Ignoring the impact of real-time prices on day-ahead market prices and the day-ahead unit commitment and calculating the billing unit effect benefits to consumers from real-time demand response based on the real-time supply curve would overstate those benefits, potentially dramatically. This is because the expectation that demand response would be activated in real-time would reduce the amount of generation committed day-ahead, which would raise the real-time price absent demand response activation above what it would otherwise be. A real-time net benefits calculation utilizing the real-time supply curve to measure the billing unit effect would be based on this inflated real-time price, so it would overstate the day-ahead market billing unit effect benefits from real-time demand response activation.

Conversely, it would not make sense for ISOs and RTOs to expend the required resources to implement a dynamic net benefits test based on the billing unit effect in real-time and incur the likely adverse software performance impact if the resulting billing unit effect benefit flowed to generators that sold power day-ahead and were dispatched down in real-time, rather than to power consumers, but there is no practical alternative to relying on virtual bidding to transfer the impact of real-time billing unit effect of demand response activation to consumers buying power in the day-ahead market.

If virtual bidding is effective in transferring the impact of real-time demand response activation to day-ahead market prices, calculating the billing unit effect benefit to consumers buying power in the day-ahead market based on the real-time supply curve will yield results that have little relationship to the actual benefits because the test applied in this would fail to account for the day-ahead market unit commitment impacts in the day-ahead market from this virtual bidding [47]

We have discussed in Section III above the complexities associated with applying a dynamic net benefits test based on the billing unit effect within the unit commitment process of a day-ahead market. Carrying out such an analysis would be unworkable in the context of a the real-time dispatch regardless of the approach used to implement a net benefits test based on the billing unit effect so it would not be feasible to use such an approach to accurately account for the billing unit effect benefits in the day-ahead market from the impact of real-time demand response on day-ahead market prices. One possible way to provide a roughly accurate measure of the day-ahead market impact would be to use off-line analysis of the relationship between the slope of the real-time supply curve and the implicit day-market supply curve to develop an adjustment factor that could be applied to the results of a net benefits test based on the billing unit effect applied to the real-time supply curve to roughly align the results of the calculation with the billing unit effect benefits in the day-ahead market.[48]

D. Interaction with market power mitigation processes

The potential activation of economic demand response in either day-ahead or real-time can impact the application of ISO and RTO market power mitigation by reducing the demand that must be met with generation and capping prices. The NYISO has run day-ahead market test cases in which a 25 megawatt reduction in demand in Zone J in the day-ahead market caused a load pocket constraint to not bind, this in turn caused mitigation to not be applied to certain generator offers, causing clearing prices to rise.

---

47 And hence estimated a benefit of P3-P2, rather than the actual benefit of P1-P2.

48 Thus, in terms of the situation illustrated in Figure 1, the idea would be to calculate the general ratio of (P1-P2) to (P3-P2) so that a scaling factor could be applied to pecuniary benefits calculated based on the real-time supply curve and hence measuring P3-P2 instead of P1-P2.

Similar outcomes would be possible in the Midwest ISO and ISO New England's implementation of conduct and impact market power tests.

Similar impacts could arise with PJM's 3 Pivotal Supplier test, the activation of demand response could reduce flows on constraints, potentially changing the outcome of the 3 Pivotal Supplier test, and causing generation offers to not be mitigated. A similar outcome would be possible with the improved local market power mitigation process which the California ISO has recently implemented in its day-ahead market and is working toward implementing in real-time, which is also based on a 3 Pivotal Supplier Test. We discuss the application of market power mitigation in combination with the net benefits test based on the billing unit effect below, first in the context of the real-time dispatch and then in the context of the day-ahead market.

Real-Time

Achieving consistent outcomes between the application of market power mitigation and the actual real-time dispatch requires that the application of market power mitigation evaluate the activation of demand response in a manner consistent with what will happen in real-time. All ISOs and RTOs, however, presently apply their tests for real-time market power mitigation in advance of the actual real-time dispatch. This sequencing is important from a software performance standpoint and also to ensure that unit commitment decisions are made based on the same bids and offers that will be used to determine the real-time dispatch.

There is an inevitable level of uncertainty in any forward looking market power mitigation process in that market conditions can change between the time that the market power evaluation is carried out and the real-time dispatch, so the degree of market power can also change. While the uncertainty associated with real-time load (and increasingly, the uncertainty associated with intermittent generation output) is unavoidable, the errors should not be consistently large and should not be predictable when generation offers were submitted.

It is impossible to assess how software developed under approach one or two to apply a net benefits test based on the billing unit effect might impact the predictability of demand response activation until that software has actually been developed, If either the first or second approach were used to implement a net benefits test based on the billing unit effect, its interaction with real-time market power mitigation designs would be one of the factors that would need to be examined under those approaches as the properties of software developed under those approaches became known.

If the third approach were used to determine the activation of demand response in real-time and applied the net benefits test based on the billing unit effect collectively to all demand response bids, this could greatly increase the unpredictability of demand response activation because that activation would be determined by an ISO or RTO wide net benefits calculation based on the billing unit effect, rather than simply based on whether the demand response bid price was less than the clearing price. With a net benefits test based on the billing unit effect in operation, the forward looking evaluation used to activate market power mitigation would not only need to accurately project market prices at the location of the demand response resources whose activation would affect the potential for the exercise of market power, it would have to accurately project prices at all locations on the grid at which prices might be impacted by demand response activation, because prices at all of these locations would impact the outcome of a net benefits test based on the billing unit effect.

The potential for high real-time prices to result from demand response that was assumed to be activated in evaluating the need for market power mitigation but not activated in real-time would be limited by the fact that a substantial ISO or RTO wide price increase resulting from the failure to apply market power mitigation in the look ahead process would almost necessarily cause demand response activation to satisfy a net benefits test based on the billing unit effect, in which case the activation of demand response in the real-time dispatch would be consistent with the assumptions in the market power evaluation. However, there may be a potential for such discrepancies between the forward evaluation and the real-time dispatch to allow the exercise of a degree of market power in some local areas.

A particular concern would be the possibility that demand response whose activation was projected in the forward market power evaluation to preclude the exercise of local market power in a transmission constraint region would not be eligible for activation in real-time because of a large amount of in merit demand response offers submitted in another region in which their acceptance would have less impact on market prices than projected in the forward market power evaluation, yet require substantial payments to demand response providers, causing demand response activation to fail a net benefits test based on the billing units effect in the real-time dispatch, allowing clearing prices to rise substantially in other transmission constrained regions when demand response is not available for activation because it fails the net benefits test.

The practical potential for such outcomes, and full assurance that there would be no circumstance in which market power mitigation would not be triggered in the forward evaluation because demand response was activated, yet large price increases could occur in real-time without triggering demand response, would require careful testing of any software based on the third approach to implement a net benefits test based on the billing unit effect and evaluation of its performance under likely congestion patterns, price levels and demand response offers.

The fourth approach in which the net benefits test based on the billing unit effect would be applied to some disaggregated locational and price level groupings of demand response bids would tend to reduce the potential for mis-forecast of prices and demand response economics in one region to cause mis-prediction of demand response activation in another region. However, the fourth approach could have other features that could contribute to poor forecasts of demand response activation in the forward market power evaluation, such as the likely need, absent development of new software algorithms, to initialize the forward looking evaluations used to apply market power mitigation further in advance of real-time in order to run some number of cases in parallel to determine demand response activation prior to the actual run that would determine market power mitigation, and other consequences of applying the net benefits test based on the billing unit effect to demand response bids that are roughly grouped by location and price that may not be apparent until such software can be tested. [49]

Given the unpredictability of a net benefits test based on the billing unit effect and a desire to avoid outcomes in which suppliers possessing locational market power are able to exercise that market power because demand response is activated in the market power test but not in the real-time dispatch, it might be that most ISOs and RTOs would choose under any approach they ultimately use to apply a net benefits test to always evaluate the application of market power mitigation in real-time assuming that no demand response would be activated. If the amount of demand response available for activation is small, this assumption would not make much difference but would result in some degree of unnecessary mitigation if the amount of real-time demand response were material. [50] Such an approach would also be consistent with the current modeling policies of some ISOs and RTOs who do not model load reductions from demand response activation in forward evaluations until those load reductions are observed in real-time demand.

Day-Ahead Markets

Implementation of a net benefit test based on the billing unit effect for demand response should not lead to unintended consequences or additional implementation issues associated with market power mitigation in day-ahead markets using the conduct and impact method to apply market power mitigation, but again may require that the Commission accept that the test will not always be accurately applied. If the net benefit test based on the billing unit effect can be applied to demand response in the initial market based pass, the same activation outcome can be applied in the mitigated and final passes.

For example, if the third approach to implementing a net benefits test based on the billing unit test were used, this would entail solving the market pass with no demand response activated, solving the market pass with all demand response activated, and then solving the subsequent market power mitigation pass and final pass with demand response either activated or not depending on the outcome in the market passes. Such an approach would ensure consistency in the evaluation of market power mitigation, but could result in a situation in which demand response would pass the net benefits test based on the billing units effect in the market pass, but would not be cost effective based on prices in the final pass if offer prices were mitigated.

---

[49] It is also possible that the inconsistencies introduced by separately analyzing the activation of demand response in multiple regions would turn out to be larger in the forward evaluation, but there does not appear to be a clear reason to anticipate that would be the case.

[50] Another possible approach to addressing the potential for inconsistent assumptions regarding demand response activation would be to move any net benefits test for demand response activation based on the billing unit effect into the same forward time frame in which market power mitigation is evaluated.

This possibility could be avoided by applying the net benefit test based on the billing unit effect to mitigated offers if mitigation were triggered, requiring that if demand response passed the net benefit test based on the billing unit effect in the market pass and market power mitigation were then triggered, the day-ahead market would be solved again using mitigated prices with no demand response activated to determine if its activation would pass the net benefits test based on the billing unit effect and mitigated prices. Solving the day-ahead market an additional time would obviously have an additional adverse impact on performance that would need to be addressed, potentially by simplifying other elements of the day-ahead market design.

If the fourth approach were used to apply a net benefits test based on the billing units effect with each locational and price based grouping of demand response bids solved in parallel, the only apparently method of implementing this approach in the day-ahead market would be to apply the net benefits test with the unit commitment fixed which would also entail applying market power mitigation prior to applying a net benefit test based on the billing unit effect to demand response offers. If this approach were taken, it would have to be accepted that market power mitigation would be applied assuming that there would be no demand response, potentially leading to the application of mitigation in some instances in which it would not have been applied had the demand response offers been taken into account.[51]

A net benefit test based on the billing unit effect could be applied using the third approach to the California ISO's day-ahead local market power mitigation in a similar manner.[52] The initial market pass would be solved both with all demand response bids available for dispatch and with none available for dispatch. These passes would then be used to determine the outcome of the net benefits test based on the billing unit effect collectively for all demand response bids. Based on this determination, binding transmission constraints would be identified based on either the case with all demand response bids available or with none available and the three pivotal supplier test applied to these constraints. As under a conduct and impact market power mitigation process there would be a potential for demand response to be cost effective based on prices in the market pass but not cost effective based on prices with mitigation applied. [53] Since the California ISO market power mitigation evaluation is applied constraint by constraint, running a fourth pass to apply a net benefits test based on the billing unit effect and utilizing mitigated prices could lead to unintended outcomes if the pivotal supplier test was applied based on the case with demand response activated and demand response then

---

51 There could be some indirect impact of the expected level of demand response bids in the day-ahead market on the unit commitment through virtual supply bids, if the impacts were fairly predictable.

52 Because the application of a net benefits test based on the billing unit effect is prospective, this discussion focuses on the California ISO's proposed local market power mitigation design, see California ISO November 16 filing in Docket ER12-423-000.

53 It is also possible, although probably not likely, that demand response could fail the net benefits test based the billing unit effect applied using unmitigated prices but pass the net benefits test based on mitigated prices. This could happen if there were demand response resources whose activation in the initial pass had little impact on clearing prices but entailed substantial payments for demand reductions but these resources activation would not be economic based on mitigated prices.

failed the net benefit test based on the billing unit effect calculated using mitigated offer prices.[54]

If the fourth approach were used to apply a net benefits test based on the billing units effect with each locational and price based grouping of demand response bids solved in parallel, the only apparently method of implementing this approach in the day-ahead market would be to apply the net benefits test with the unit commitment fixed, which would also entail applying the pivotal supplier test prior to applying a net benefit test based on the billing unit effect to demand response offers as discussed above. If this approach were taken, it would have to be accepted that the pivotal supplier test would be applied assuming that there would be no demand response, possibly leading to occasional mitigation of offers by suppliers that would not have been mitigated had demand response been taken into account.[55]

A similar approach could be used to apply the net benefit test based on the billing unit effect in conjunction with PJM's three pivotal supplier test in the PJM day-ahead market, solving the market with demand response available then not available and using the applicable case to determine constraints to which the three pivotal supplier test would be applied. As in the California ISO market power mitigation design, there would be a potential for demand response activation to pass the net benefits test based on the billing unit effect utilizing prices determined in the initial unmitigated pass but to fail the test based on mitigated prices. As with the California ISO, attempting to resolve this inconsistency could lead to unintended consequences as well as adversely impacting day-ahead market performance.

Hence, the net benefit test based on the billing unit effect could be applied to day-ahead market in conjunction with existing market power mitigation designs without any additional substantial adverse impacts on market performance or risk of anomalous outcomes, as long as the Commission is willing to allow ISOs and RTOs to apply the net benefit test utilizing unmitigated offer prices and not require that the billing unit effect be recalculated if mitigation is applied.

E. Impact on intra-day look-ahead scheduling and unit commitment evaluations.

ISOs such as the New York ISO and California ISO that schedule imports and exports on an economic basis intra-day (RTC and HASP) will need to account for the impact of economic demand response in their forward scheduling evaluations to avoid inefficient scheduling and commitment decisions that would raise consumer costs. Failure to

---

54 By the nature of a net benefits test based on the billing unit effect, there should not be a large overall increase in prices as a result of a failure to activate demand response under the third approach, but it is possible that making demand response unavailable for dispatch could create a situation in which some local market power exists absent demand response and could be exercised.

55 As noted above, there could be some indirect impact of the expected level of demand response bids in the day-ahead market on the unit commitment through virtual supply bids, if the impacts were fairly predictable.

correctly forecast the activation of demand response could cause the New York ISO and California ISO to schedule costly imports, then dispatch down internal generation with lower offer prices in real-time when demand response is activated.

New York ISO, California ISO and PJM also use look-ahead scheduling software to make commitment decisions for 10 and 30 minute gas turbines and some combined cycle units during the operating day and these evaluations would similarly need to account for economic demand response activation decisions in making these commitment decisions. ERCOT, ISO New England and MISO are moving towards implementation of such look-ahead scheduling software over the next few years.

The ability of these look-ahead scheduling and commitment evaluations to correctly project future demand would be adversely impacted by any additional uncertainty regarding demand response activation that would be introduced by the net benefits test based on the billing unit effect, just as discussed in section D with respect to market power mitigation. It cannot be projected at this time how any implementation of the net benefit test based on the billing unit effect developed under approaches one or two might impact predictability, but if a dynamic net benefits test based on the billing unit effect were implemented using the third approach, either activating all or none of the demand response that is economic based on its bid price, this could tend to magnify the potential prediction errors.

If the amount of economic demand response potentially activated is material, the ISOs and RTOs would ideally want to account for it in these look-ahead scheduling decisions so they could make cost effective short-term commitment and scheduling decisions. This would not be important if the amount of economic demand response is not material, but if the amount of economic demand response is not material, it would not be cost effective for ISOs and RTOs to incur the software costs required to implement such a dynamic net benefit test based on the billing unit effect in order to activate an immaterial amount of demand response.

As ISO-NE and NY, NY and PJM, and PJM and MISO move to implement ISO and RTO coordinated 15 minute interchange scheduling, all of these ISOs and RTOs will need to account for economic demand response activation in their interchange scheduling decisions, which will be greatly complicated and potentially unable to achieve the intended goals if demand response activation must be determined by application of a net benefit test based on the billing unit effect. A fundamental step in these coordinated interchange scheduling processes is the calculation of the projected cost of interchange in future intervals, to be used in creating supply curves that determine the least cost interchange level. The bids of demand response resources would ideally be taken into account in developing these supply curves. However, it is not apparent how an ISO or RTO could determine whether to include demand response bids in the supply curve if activation would depend on the outcome of a net benefit test based on the billing unit effect. Attempting to calculate the outcome of a net benefit test based on the billing unit effect for each level of interchange evaluated in constructing the forward supply curves would make this process so complex and time consuming that it may push the time frame for these evaluations forward in time, defeating the goal of implementing ISO and RTO coordinated interchange in order to more closely attune schedules with current market conditions.

The only apparent option for constructing supply curves for coordinated interchange scheduling in these circumstances would be to simply ignore economic demand response in constructing the interchange supply curves, which would contribute to additional price divergence between the actual and projected supply curves and less optimal interchange schedules if demand response were material, reducing the benefits of implementing these coordinated interchange designs.

It would also be completely unworkable to account for the impact of activating demand response on future interchange levels in applying a net benefits test based on the billing unit effect, so the way the billing unit effect benefits would have to be calculated would tend to overstate the billing unit effect because it would not account for the increase in exports and reduction in imports associated with lower clearing prices.

Implementation of these ISO and RTO coordinated interchange scheduling designs would be further complicated by the need to isolate the optimization function in these designs from the calculations related to the net benefit test based on the billing unit effect. The objective of these changes in interchange scheduling designs is to improve production efficiency by converging prices across ISOs and RTOs, but an individual ISO or RTO can achieve the objective of depressing energy market clearing prices by scheduling uneconomic imports and not scheduling economic exports, actions which have a billing unit effect benefit but tend to cause ISO and RTO prices to diverge. Unintended interactions between the billing unit effect calculations in the net benefit test and these interchange scheduling designs have the potential to produce unintended consequences that could delay or even foreclose implementation of one or the other of these programs.

Moreover, if there are material amounts of economic demand response, the ISOs and RTOs will have to carefully examine the design and implementation of these forward evaluations to make sure that omitting economic demand response in forward looking evaluations does not create the potential for inefficient market participant bidding strategies designed to profit from differences between the load forecast in the forward looking evaluation and the actual real-time load.

Another complication arising with the application of a net benefit test based on the billing unit effect to demand response would be the need to relate the unit commitment decisions in these look-ahead unit commitment decisions to those made in the day-ahead market. Because of the links between the day-ahead market and real-time prices that were discussed in section C above, if ISOs and RTOs depress day-ahead market prices by activating demand response only in the final dispatch step in the day-ahead market after the day-ahead unit commitment is fixed, realizing the billing unit effect requires maintaining this excess commitment in real-time.[56] Maintaining this excess capacity in

---

[56] If the generation scheduled to operate in the day-ahead market were consistently not committed in real-time, this would tend to raise real-time prices relative to day-ahead prices, inducing the submission of

the real-time dispatch and maintaining consistency between day-ahead prices and expected real-time prices would require that ISO and RTO look-ahead evaluations in some manner accommodate the commitment of uneconomic generation to depress real-time prices in line with day-ahead market prices. While accomplishing this objective would likely not require development of new solution methods as under the first two approaches, it could require fairly significant redesign of these look-ahead commitment tools to achieve this purpose and could require that the ISOs and RTOs incur substantial costs in order to implement these software changes.

Moreover the potential complexity of developing software that would not minimize production costs to the extent this would undo the billing rate effect of demand response activation in the day-ahead market but would somehow minimize production costs with respect to other scheduling and commitment decisions has the potential to make the process of developing this software lengthy and expensive with the potential for surprise unintended consequences that inflict substantial costs on power consumers.

F. Interaction with Ramp Capability Products

The California ISO and Midwest ISO are currently developing ramp capability products that will entail optimizing dispatch over multiple dispatch intervals so as to maintain ramp capability in future intervals. These forward dispatch evaluations differ from the inter-temporal optimization discussed in subsection B above in that they are designed to maintain ramp capability to respond to unforeseen demand uncertainty and supply variability, while conventional inter-temporal optimization dispatches the system to better respond to known future demand and supply changes.

The implementation of these ramp capability products is potentially important to enabling ISOs and RTOs to better manage of the reliability and economic impacts of increased intermittent generation output on the transmission system. The essence of their design is to dispatch generation slightly out of merit in order to create additional upward or downward ramping capability when the available ramping capability would otherwise fall below target levels.[57]

The implementation of a dynamic net benefit test based on the billing unit effect could potentially hamper the implementation of these ramp capability products in two ways. First, any adverse software performance impact from implementing a dynamic net benefit test based on the billing unit effect using either the third or fourth approach, could make it impossible to implement market design improvements such as these ramp capability products, because some ISO and RTO dispatch software may not be able to execute all of these functions within an acceptable time frame from a real-time dispatch software performance standpoint.

---

virtual demand bids the day-ahead market which would tend to raise day-ahead market prices, offsetting some of the impact of the demand response.

[57] See Lin Xu and Donald Tretheway, California ISO, Flexible Ramping Products, Draft Final Proposal, April 9. 2012; and Nivad Navid, Gary Rosenwald and Dhiman Chatterjee, Midwest ISO, "Ramp Capability for Load Following in the MISO Markets," July 15, 2011.

Second, the current conceptual framework for implementing a ramp capability product, both creating additional ramp for use in future intervals and then making that extra ramp available for dispatch, is based on the use of penalty values for ramp that would be incorporated in the current benefit test based on a production cost minimizing objective function. [58] This approach would not be consistent with an objective function for demand response activation that is based on a billing unit effect benefit calculation, yet activation of demand response could have a material impact on the ramp needs and ramp availability of the system. While the activation of demand response that provides additional low cost ramp capability would likely at times also reduce energy payments to generators, it is not clear whether that would be a general outcome, or whether activation could instead leave the price of inflexible energy unchanged but impact the price and amount of ramp capability on the system. On the other hand, paying LMP for demand reductions that serve to create additional ramp could lead to high cost outcomes for power consumers if that cost is not taken into account in the objective function in dispatching demand response to maintain ramp.

Trying to design an ad hoc method for achieving efficient outcomes from these ramp capability designs from the standpoint of maintaining ramp capability and maintaining the system's ability to respond to demand and supply shocks based on a net benefit calculation based on the billing unit effect for demand response activation has the potential to both greatly complicate the implementation process and give rise to unintended consequences when the RTOs ultimately implement these designs.

V. Alternative Settlement Approach

The discussion in sections III and IV of implementation issues associated with a dynamic net benefits test based on the billing unit effect is premised on the result of the test being used to determine whether demand response that has submitted a bid price that is less than the clearing price at its location would be dispatched. Several statements by the Commission in orders related to Order 745 suggest that FERC does not in fact intend that demand response activation be conditioned on the outcome of the net benefits test in addition to a demand response resource's bid price, but only be conditioned on the demand response resource's bid price.

Thus, FERC stated in Paragraph 131 of Order 745A: "We clarify that pursuant to this section 206 directive, each RTO and ISO must revise its tariff to provide that when the LMP is greater than or equal to the threshold price, all demand resources that qualify for compensation will receive the LMP payment. The Commission's section 206 action in Order No 745 did not extend, however, to situations where the LMP is not greater than or equal to the threshold price. Thus, if LMP is less than the threshold price, the Final Rule does not apply to determine the payment to a demand response resource, and any payment will be governed by the existing RTO or ISO tariff."

---

[58] Ibid

[59] See 137 FERC Para 61,217 Docket ER11-4100-000.

One interpretation of this statement is that the decision to activate demand response under order 745 should not depend on the outcome of the net benefit test based on the billing unit effect, and that only the level of compensation depends on the outcome of the net benefits test based on the billing unit effect.

Paragraph 127 of Order 745A similarly indicates that the activation decision would be based solely on the offer price, stating that “The Commission does not expect that a demand response provider will know the magnitude of the billing unit effect associated with its demand reduction ex ante, but if it bids its marginal opportunity cost (as we would expect in a competitive market), it will only be called when it is in the demand response provider’s economic interest to reduce consumption.”

There is similar language in the California ISO compliance filing order,[59] in which paragraph 31 states: “Order 745 did not direct RTOs and ISOs to reject demand response bids below the threshold price, nor did it determine that only bids at or above the threshold price could result in cost-effective demand reductions. Rather, under Order No 745, when the LMP is greater than or equal to the threshold price, all demand response resources that qualify for compensation will receive the LMP payment.”[60]

FERC’s Order on PJM’s Compliance filing,[61] and on the Midwest ISO’s compliance filing,[62] contain similar statements indicating that demand response bids that do not satisfy a net benefits test based on the billing unit effect would be activated and compensated according to relevant tariff provisions

The distinction between demand response which must be dispatched based on the outcome of the net benefits test based on the billing unit effect and demand response which must be compensated based on the outcome of a net benefits test based on the billing units effect is extremely significant in the context of the workability of such a net benefits test. If the activation of demand response in the real-time dispatch does not depend on the outcome of a net benefits test based on the billing unit effect, there is no need for a dynamic net benefits test based on the billing units effect in the sense of a test carried out as part of the economic dispatch or in the process of clearing the day-ahead market, the net benefit test based on the billing units effect could instead be carried out as a settlement function.

Several of the implementation issues discussed in section III cease to be implementation issues at all if the net benefits test based on the billing unit effect is to be applied after the fact in a settlement process, while the others would be more manageable if addressed in an after the fact settlement process. In particular, issues regarding accounting for special ISO and RTO pricing rules, interaction with market power mitigation processes, the impact on intra-day look ahead scheduling and commitment processes , accounting for

---

59 See 137 FERC Para 61,217 Docket ER11-4100-000.

60 Paragraph 32 has additional language regarding the need for a 205 filing by the CAISO to address compensation for demand response with bids that fail a net benefits test based on the billing unit effect.

61 See 137 FERC Para 61,216 December 15, 2011 at 16

62 See 137 FERC Para 61,212 December 15. 2011 at 37.

inter-temporal dispatch impacts, and the impact on ramp capability dispatch and scheduling algorithms would be completely avoided.

There would still be complexities associated with implementing a net benefits test based on the billing unit effect on a congested transmission grid and accounting for interactions between demand response and the unit commitment that would likely warrant some simplifications to reduce the cost of implementing such test in the settlement system, but these complexities would not entail the development of new optimization solution methods or algorithms. Attempting to accurately account for interactions between real-time demand response and day-ahead market prices in applying the net benefit test based on the billing unit effect would also still be complex even in an after the fact settlement process, but implementation would be more manageable in an after the fact time frame, and its implementation would not adversely impact the performance of ISO and RTO real-time dispatch software or day-ahead markets.

Hence, it is very important to clarify what the Commission intends regarding a dynamic net benefits test based on the billing unit effect. If the Commission does not intend that the availability of demand response resources for dispatch be based on the result of a net benefits test based on the billing unit effect, but intends only that the amount of payment for demand response depend on the net benefits test based on the billing unit effect, then there is no need for this net benefits test to be carried out as a dynamic process as part of the real-time dispatch or day-ahead market. It can instead be carried out as a settlements process, in a settlements time frame, and avoid many complex interactions with elements of ISO and RTO day-ahead market and real-time dispatch.

VI. Recommendations

Five approaches for implementing order 745 have been discussed in this paper. Four of the approaches are alternative ways of applying a net benefits test based on the billing unit effect to determine the activation of demand response in the real-time dispatch or in the day-ahead market. The fifth approach would be to apply this test in a settlements process carried out after the fact, and to base the activation of demand response bids in the real-time dispatch and day-ahead market solely on ISO and RTO market prices and the bids of demand response resources.

The second approach discussed in Section III, developing new solution methods for a net benefits test based on the billing unit effect and then developing new software based on those new methods, is the best approach from the standpoint of ultimately providing unit commitment and dispatch solutions based on the net benefits test and the billing unit effect that could be implemented in ISO and RTO real-time dispatch and day-ahead market software with the fewest compromises to ISO and RTO operations and the least adverse impact on the cost of meeting load. However, this approach entails an initial research effort whose results and timeline cannot be predicted. Hence, there cannot be fixed timeline for the implementation of a net benefits test based on the billing unit effect in ISO and RTO software if this approach is selected.

The first approach discussed in Section III, developing new software applying known methods, is also in part a research effort and therefore has an undefined timeline and results. The implementation time line may be somewhat shorter than under the second approach because this approach would focus on known methods, but it is not known for sure if those methods will eventually produce a satisfactory solution in a time frame that would be acceptable from the standpoint of ISO and RTO software performance.

The third approach, modifying existing software to apply a net benefits test based on the billing unit effect on an all or nothing basis would likely have the shortest timeline to implementation and the most certainty that the approach could be implemented. However, the all or nothing application of a net benefits test based on the billing unit effect would have an inherent potential for in merit demand response to not be eligible for dispatch at one location because demand response offered at another location failed a net benefit test based on the billing unit effect. Moreover, the potential unpredictability of the outcome of a net benefit test based on the billing unit effect applied in this manner might make it impossible to take account of demand response in many ISO and RTO forward looking evaluations, including those used for market power mitigation, interchange scheduling and real-time unit commitment. Hence, this approach should only be adopted if is important to implement this aspect of Order 745 in the near term.

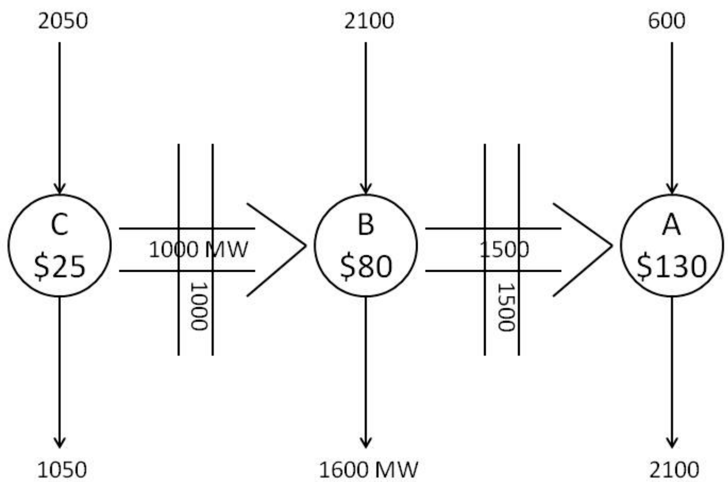
The fourth approach, modifying existing software to apply a net benefits test based on the billing unit effect to groups of demand response bids would likely have a somewhat longer timeline to implementation and more overall implementation risk than the third approach because of the more complex software design required to implement this approach. The advantage of this approach is that it should produce fewer anomalies in the application of the net benefits test because of the somewhat disaggregated application, but how material this difference would be cannot be assessed until the software is developed and could vary between ISOs and RTOs depending on bidding and congestion patterns.

The fifth and final approach discussed in Section VI would be to apply the net benefits test in the settlement system. This would by far be the approach with the shortest timeline and lowest implementation cost. It would also have the least adverse impact on ISO and RTO operations, as it would not adversely impact any current or prospective look-ahead dispatch or commitment evaluations. The critical factor with this approach is simply whether it is consistent with the Commission's intentions.

Appendix A

We begin with a simple radial example. Figure A-1 portrays the dispatch of simple transmission system with no activation of demand response. The price of power is $130 at A, $80 at B and $25 at C.

Figure A-1
Dispatch with No Demand Response



The offers of the generation resources at each location are portrayed in Table A-2.

Table A-2

Supply at A

325 MW at $100
100 MW at $115
100 MW at $120
100 MW at $130

Supply at B

1525 MW at $40
50 MW at $45
50 MW at $50
50 MW at $55
50 MW at $60
50 MW at $65
50 MW at $70
50 MW at $75
50 MW at $80

Supply at C

1525 MW at 0
200 MW at $5
100 MW at $10
100 MW at $15
100 MW at $20
100 MW at $25
100 MW at $30

Table A-3 shows the total gross payments by load of $427,250, congestion rents of $130,000, and total payments to generation of $297,250. Because congestion rents flow back to power consumers directly or indirectly in the market designs of US ISOs and RTOs and net cost to load is $297, 250, which is equal to the payments to generators.[63]

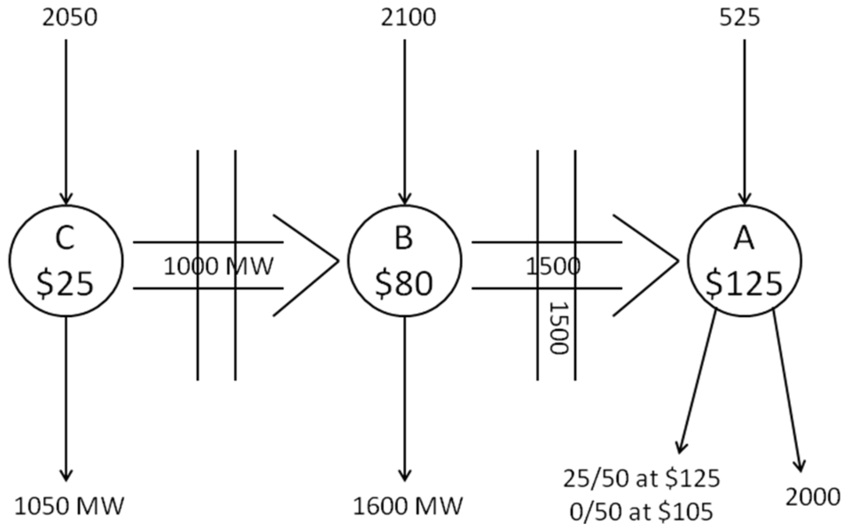
Table A-3
Payments by Load with no Demand Response

	Load	Price	Gross Load Payment	Generator Output	Generator Revenues
C	1050	25	$26,250	2050	$51,250
B	1600	80	$128,000	2100	$168,000
A	2100	130	$273,000	600	$78,000
Total	4750		$427,250	4750	$297,250
Congestion Rents		C-B	1000	$55	$55,000
		B-A	1500	$50	$75,000
		Total			$130,000
Net Load Cost					$297,250

Now suppose that there were 50 megawatts of demand response at A with a bid price of $105 and another 50 megawatts with a bid price of $125. The demand response with a bid price of $105 would be dispatched first, reducing load at A to 2050 megawatts and requiring the dispatch of 550 megawatts of generation at A. Since 25 megawatts of the generation offered at $130 would still be needed to meet load, the price of power at A would still be $130. It would therefore be economic to dispatch another 25 megawatts of the demand response bid in at $125, causing the price at A to fall to $125 as shown in Figure A-4.

63 While the details vary by ISO and RTO, in general, day-ahead market congestion rents flow back directly to consumers to the extent FTRs or grandfathered rights are assigned to or held by consumers and indirectly to the extent FTRs, CRRs or TCCs are auctioned with auction revenues credited back against transmission access charges or other RTO costs. Similarly, real-time congestion rent surpluses and shortfalls are generally allocated back largely to power consumers.

Figure A-4
Dispatch with Demand Response at A



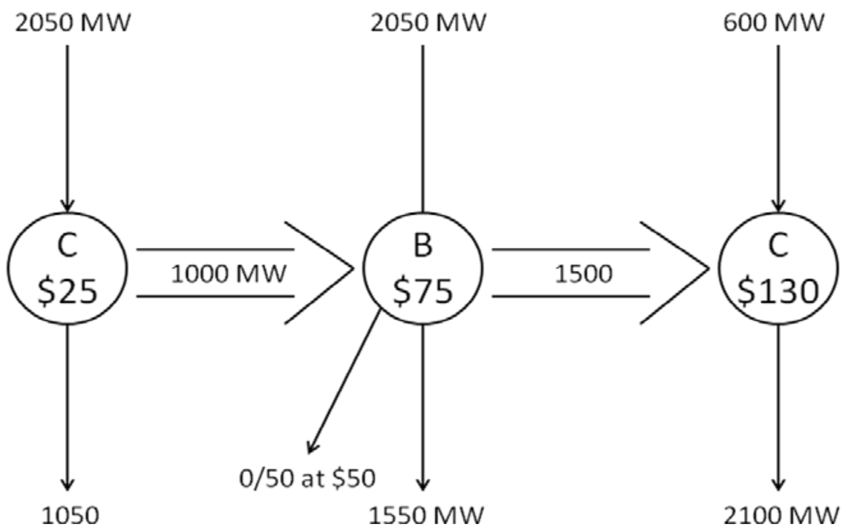
The dispatch of the demand response at A would cause the price of power at A to fall by $5 per megawatt hour (from $130 to $125 – set by the partially dispatched demand response bid), the price paid by consumers at B and C would remain unchanged, as would the price paid to generation at B and C, so there would be no billing unit effect benefit to the consumers at B and C from the activation of demand response at A. Applying the net benefits test based on the billing unit effect to the demand response at A, the change in price at A would be -$5, reducing payments to 525 megawatts of generation at A. Total congestion rents would also fall so the net cost of load would fall from $297,250 to $284,875. $9750 of the reduction in load payments would be the reduced payments by the demand response load, so the change in the cost to the remaining load (i.e. the billing unit effect or the pecuniary benefit to power consumers from the price reduction) would be $2625), and the payments to the demand response would be $125 per megawatt on 75 megawatts of demand response (for a total cost of $9375), so the payments to the demand response would considerably exceed the billing unit effect benefits to power consumers, as shown in Table A-5.

Table A-5
Payments by Load with Demand Response at A

	Load		Payment	Gen	Payment
C	1050	25	26250	2050	51250
B	1600	80	128000	2100	168000
A	2025	125	253125	525	65625
	4675		407375	4675	284875
Benefit	2025	-5	-10125	525	-2625
DR Cost	75	125	9375	75	9375
Net			-750		6750

Alternatively, suppose that instead of the demand response at A there were 50 megawatts of demand response offered at B, bid at $50. This demand response would be activated and displacing 25 megawatts of generation offered at $80 and 25 megawatts offered at $75, dropping the price at B to $75 as shown in Figure A-6. Given the transmission congestion between A and B and between B and C, the price of power at A and C would be unaffected by the activation of the demand response at B in this example.

Figure A-6
Dispatch with Demand Response at B



The activation of the demand response at B would pass the net benefits test. The demand response would reduce the net payments by load to $283,000 ($415,500 in gross payments less $132,500 in congestion rents). $4,000 of the $14,250 reduction in net payments by load would be reduced payments by demand response, so the total reduction in payments by remaining load would be $10,250.

The payments to the demand response for not consuming would be only $3750 (50 megawatts * $75 per megawatt), so the reduction in payments to generation would greatly exceed the extra payments to the demand response providers, by $6500, as shown in table A-7.

Table A-7
Payments by Load with Demand Response at B

	Load	Price	Gross Load Payment	Generator Output	Generator Revenues
A	1050	25	$26,250	2050	$51,250
B	1550	75	$116,250	2050	$153,750
C	2100	130	$273,000	600	$78,000
	4700		$415,500	4700	$283,000
Congestion Rents		C-B	1000	$50	$50,000
		B-A	1500	$55	$82,500
		Total			$132,500
Net Cost to Load					$283,000
Original Net Cost					$297,250
Reduced Payments by demand response load					
		at B	50	$80	$4,000
Change in Cost to Remaining Load					$10,250
Demand Response Cost			50	$75	$3,750
Net Benefit to Remaining Load					$6,500

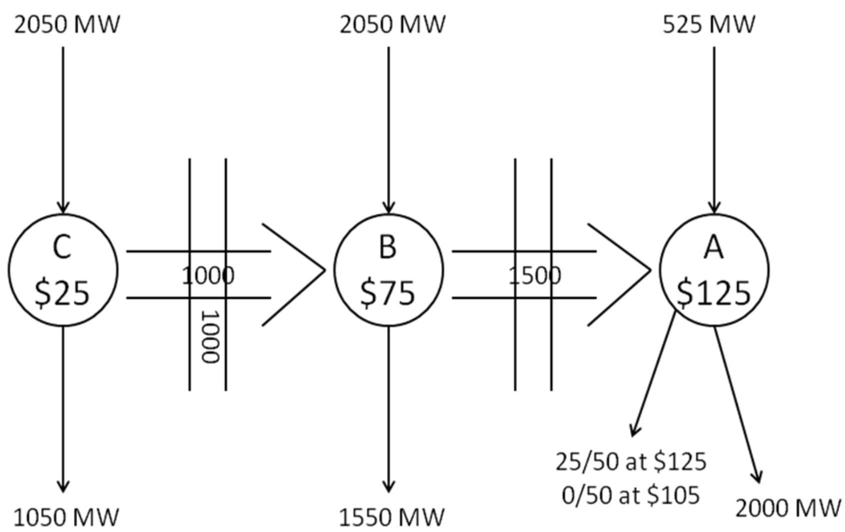
It is noteworthy that if the hypothesized demand response were available at both A and B and the net benefits test were applied to combined impact of all demand response, the demand response would fail the net benefits test. The change in cost to remaining load would be a reduction of $12,875, but the cost of the demand response would be $13,125 ($9375 + $3750) exceeding the billing unit effect by $250 shown in Table A-8.

Table A-8
Payments by Load with Demand Response at A and B

	Load	Price	Gross Load Payment	Generator Output	Generator Revenues
A	1050	25	$26,250	2050	$51,250
B	1550	75	$116,250	2050	$153,750
C	2025	125	$253,125	525	$65,625
	4625		$395,625	4625	$270,625
Congestion Rents		C-B	1000	$50	$50,000
		B-A	1500	$50	$75,000
		Total			$125,000
Net Load Cost					$270,625
Original Net Cost					$297,250
Reduced payments by demand response load					
		at A	75	$130	$9,750
		at B	50	$80	$4,000
Change in Gross Cost to Remaining Load					$12,875
Demand Response Cost					
		at A	75	$125	$9,375
		at B	50	$75	$3,750
Net Benefit to Remaining Load					-$250

Hence, in this example, portrayed in Figure A-9 below, the existence of additional demand response at A would cause the demand response at B to not be activated if the net benefits test based on the billing unit effect were applied jointly to all demand response.

Figure A-9
Dispatch with Demand Response at A and B



The presence of congestion can cause activation of demand response based on a net benefits test based on the billing unit effect applied collectively to all demand response to produce even more unintuitive outcomes with respect to demand response activation if there are changes in the level of congestion from interval to interval.

We have seen above that given the congestion pattern portrayed in Figure A-9, the combined activation of the demand response at A and B would not pass the net benefits test. Suppose, however, that load was lower at A so the transmission constraint between A and B would bind at a lower shadow price absent demand response as shown in Figure A-10 (the shadow price of the B-A constraint is $40 in Figure A-10, compared to $50 in Figure A-1).

Figure A-10
Dispatch with No Demand Response
Lower Demand

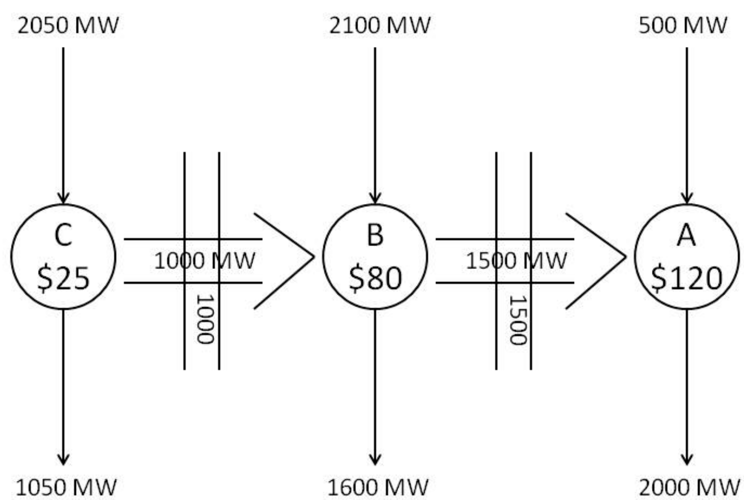


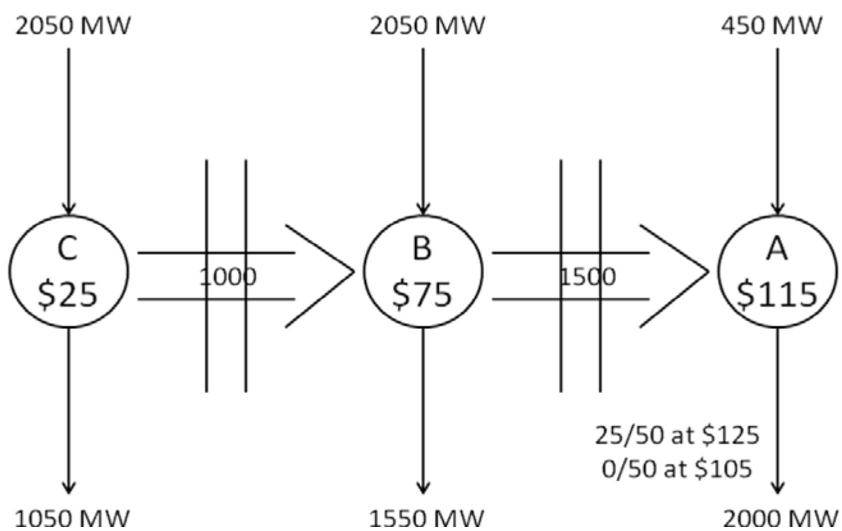
Table A-11 shows the net cost to load would be $279,250 at this reduced level of load.

Table A-11
Payments by Load with Lower Congestion

	Load	Price	Gross Load Payment	Generator Output	Generator Revenues
C	1050	25	$26,250	2050	$51,250
B	1600	80	$128,000	2100	$168,000
A	2000	120	$240,000	500	$60,000
Total	4650		$394,250	4650	$279,250
Congestion Rents		C-B	1000	$55	$55,000
		B-A	1500	$40	$60,000
		Total			$115,000
Net Load Cost					$279,250

At the lower prices at A, only 50 megawatts of demand response at A would have bids below the clearing price and be dispatched in applying a dynamic net benefits test based on the billing unite effect as shown in Figure A-12.

Figure A-12
Dispatch with Demand Response
Lower Demand



Even with this reduced level of demand response at A and the lack of any price impact from the demand response at A, the net benefits test for demand response at A and B would be satisfied with a billing unit effect in terms of reduced payments by remaining load of $12,500 and payments to demand response providers of $9,500 ($5750 + $3750) as shown in Table A-13, producing a net benefit of $3000. Hence the demand response would be eligible to be activated and paid the LMP price at its location.

Table A-13
Payments by load with Lower Demand and Demand Response

	Load	Price	Gross Load Payment	Generator Output	Payment
C	1050	25	$26,250	2050	$51,250
B	1550	75	$116,250	2050	$153,750
A	1950	115	$224,250	450	$51,750
	4550		$366,750	4550	$256,750
Congestion Rents		C-B	1000	$50	$50,000
		B-A	1500	$40	$60,000
		Total			$110,000
Net Cost to Load					$256,750
Original Net Cost					$279,250
Reduced Payments by demand response load					
		at A	50	$120	$6,000
		at B	50	$80	$4,000
Change in Cost to Remaining Load					$12,500
Demand Response Cost					
		at A	50	$115	$5,750
		at B	50	$75	$3,750
Net Benefit to Remaining Load					$3,000

The potential for disparate outcomes to a net benefits test in the presence of transmission congestion as illustrated in these simple examples is inherent in applying a dynamic net benefits test based on the billing unit effect using either of the ad hoc approaches described in the body of this report, because either approach would entail a degree of aggregation across demand response bids in applying the net benefits test based on the billing unit effect.